1. Factory test power factor correction equipment before shipment. Comply with NEMA CP 1. Include the following:
   a. Routine capacitor production tests, including short-time overvoltage, capacitance, leak, and dissipation-factor tests.
   b. Functional test of all operations, controls, indicators, sensors, and protective devices.

1.3 EXECUTION

A. Installation
1. Install freestanding equipment on concrete bases. Cast-in-place concrete is specified in Division 3.
2. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
3. Maintain minimum workspace according to manufacturer's written instructions.
4. Connect remote monitoring communication module to electrical power monitoring and control data network through appropriate network interface unit.
5. Identify components according to Division 26 Section "Identification For Electrical Systems".

B. Field Quality Control
1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
2. Perform tests and inspections.
3. Tests and Inspections: Perform each visual and mechanical inspection and electrical test stated in the following Sections, except optional tests, in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   a. Current Transformers.
   b. Capacitors and Reactors, Capacitors.

C. Startup Service
1. Perform startup service.
   a. Complete installation and startup checks according to manufacturer's written instructions.
   b. Connect and run installed motors and equipment to verify the automatic switching of the capacitors. Verification shall include automatic switching of the total capacity of installed capacitors.
      1) Provide sufficient inductive/reactive load banks, in combination with resistive load banks, for the test.

D. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain automatic power factor correction units.

END OF SECTION 26 35 33 16

Task	Specification	Specification Description
26 35 33 16	26 09 23 00b	Electrical Power Monitoring And Control
26 35 53 00	26 32 13 13	Packaged Engine Generators

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SECTION 26 36 13 00 - TRANSFER SWITCHES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for transfer switches. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes transfer switches rated 600 V and less, including the following:
   a. Automatic transfer switches.
   b. Bypass/isolation switches.
   c. Nonautomatic transfer switches.
   d. Remote annunciation systems.
   e. Remote annunciation and control systems.

C. Submittals
1. Product Data: Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
3. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems". Include the following:
4. Field quality-control test reports.
5. Operation and maintenance data.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NEMA ICS 1.
3. Comply with NFPA 70.
4. Comply with NFPA 99.
5. Comply with NFPA 110.
6. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.2 PRODUCTS

A. General Transfer-Switch Product Requirements
1. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
2. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
   a. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
3. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

4. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
5. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
6. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
   a. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
   b. Switch Action: Double throw; mechanically held in both directions.
   c. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.
7. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles **OR** overlapping neutral contacts, **as directed**.
8. Neutral Terminal: Solid and fully rated, unless otherwise indicated.
9. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.
10. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.
11. Battery Charger: For generator starting batteries.
    a. Float type rated 2 **OR** 10, **as directed,** A.
    b. Ammeter to display charging current.
    c. Fused ac inputs and dc outputs.
12. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.
13. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 26 Section "Identification For Electrical Systems".
    a. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
    b. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
    c. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
14. Enclosures: General-purpose NEMA 250, Type 1 **OR** 3R **OR** 12, **as directed**, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

B. Automatic Transfer Switches
1. Comply with Level 1 equipment according to NFPA 110.
2. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
3. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.
4. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.
5. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
6. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
7. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.
8. Automatic Closed-Transition Transfer Switches: Include the following functions and characteristics:

a. Fully automatic make-before-break operation.
b. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
c. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.
   1) Initiation occurs without active control of generator.
   2) Controls ensure that closed-transition load transfer closure occurs only when the 2 sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.
d. Failure of power source serving load initiates automatic break-before-make transfer.

9. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
10. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.
11. Programmed Neutral Switch Position: Switch operator has a programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Pause is adjustable from 0.5 to 30 seconds minimum and factory set for 0.5 second, unless otherwise indicated. Time delay occurs for both transfer directions. Pause is disabled unless both sources are live.
12. Automatic Transfer-Switch Features:
    a. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
    b. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
    c. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
    d. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
    e. Test Switch: Simulate normal-source failure.
    f. Switch-Position Pilot Lights: Indicate source to which load is connected.
    g. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
       1) Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
       2) Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
    h. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
    i. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.

j. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
k. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
l. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
m. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
    1) Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    2) Push-button programming control with digital display of settings.
    3) Integral battery operation of time switch when normal control power is not available.

C. Bypass/Isolation Switches
1. Comply with requirements for Level 1 equipment according to NFPA 110.
2. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
    a. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.
    b. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations.
    c. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
    d. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
    e. Operability: Constructed so load bypass and transfer-switch isolation can be performed by 1 person in no more than 2 operations in 15 seconds or less.
    f. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
    g. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.
3. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

D. Nonautomatic Transfer Switches
1. Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternate Source." Switch shall be capable of transferring load in either direction with either or both sources energized.
2. Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternate Source." In addition, removable manual handle provides quick-make, quick-break manual-switching action. Switch shall be capable of electrically or manually transferring load in either direction with either or both sources energized. Control circuit disconnects from electrical operator during manual operation.
3. Double-Throw Switching Arrangement: Incapable of pauses or intermediate position stops during switching sequence.

4. Nonautomatic Transfer-Switch Accessories:
   a. Pilot Lights: Indicate source to which load is connected.
   b. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and alternate-source sensing circuits.
      1) Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
      2) Emergency Power Supervision: Red light with nameplate engraved "Alternate Source Available."
   c. Unassigned Auxiliary Contacts: One set of normally closed contacts for each switch position, rated 10 A at 240-V ac.

E. Remote Annunciator System
1. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches. Annunciation shall include the following:
   a. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
   b. Switch position.
   c. Switch in test mode.
   d. Failure of communication link.
2. Annunciator Panel: LED-lamp type with audible signal and silencing switch.
   a. Indicating Lights: Grouped for each transfer switch monitored.
   b. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
   c. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.
   d. Lamp Test: Push-to-test or lamp-test switch on front panel.

F. Remote Annunciator And Control System
1. Functional Description: Include the following functions for indicated transfer switches:
   a. Indication of sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
   b. Indication of switch position.
   c. Indication of switch in test mode.
   d. Indication of failure of digital communication link.
   e. Key-switch or user-code access to control functions of panel.
   f. Control of switch-test initiation.
   g. Control of switch operation in either direction.
   h. Control of time-delay bypass for transfer to normal source.
2. Malfunction of annunciator, annunciation and control panel, or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically reverts to stand-alone, self-contained operation. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation.
3. Remote Annunciation and Control Panel: Solid-state components. Include the following features:
   a. Controls and indicating lights grouped together for each transfer switch.
   b. Label each indicating light control group. Indicate transfer switch it controls, location of switch, and load it serves.
   c. Digital Communication Capability: Matched to that of transfer switches supervised.
   d. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.

G. Source Quality Control
1. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

1.3 EXECUTION

A. Installation
1. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section "Hangers And Supports For Electrical Systems".
2. Floor-Mounting Switch: Anchor to floor by bolting.
   a. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 26 Section "Hangers And Supports For Electrical Systems".
3. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.
4. Identify components according to Division 26 Section "Identification For Electrical Systems".
5. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

B. Connections
1. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to the Owner if necessary to accommodate required wiring.
2. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
3. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
2. Perform tests and inspections and prepare test reports.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
   b. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
   c. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   d. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
      1) Check for electrical continuity of circuits and for short circuits.
      2) Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
      3) Verify that manual transfer warnings are properly placed.
      4) Perform manual transfer operation.
   e. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
      1) Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
      2) Simulate loss of phase-to-ground voltage for each phase of normal source.
      3) Verify time-delay settings.
      4) Verify pickup and dropout voltages by data readout or inspection of control settings.
      5) Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.

6) Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

f. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

1) Verify grounding connections and locations and ratings of sensors.

3. Coordinate tests with tests of generator and run them concurrently.
4. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
5. Remove and replace malfunctioning units and retest as specified above.
6. Infrared Scanning: After Final Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.
   a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Final Completion.
   b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   c. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

D. Demonstration
   1. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below.
   2. Coordinate this training with that for generator equipment.

END OF SECTION 26 36 13 00

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Task	Specification	Specification Description
26 36 13 00	26 24 13 00a	Enclosed Switches And Circuit Breakers
26 36 23 00	26 24 13 00a	Enclosed Switches And Circuit Breakers
26 36 23 00	26 36 13 00	Transfer Switches
26 41 13 13	26 05 26 00	Lightning Protection

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SECTION 26 43 13 00 - TRANSIENT VOLTAGE SUPPRESSION

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for transient voltage suppression. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes field-mounted TVSS for low-voltage (120 to 600 V) power distribution and control equipment.

C. Definitions
1. ATS: Acceptance Testing Specifications.
2. SVR: Suppressed voltage rating.
3. TVSS: Transient voltage surge suppressor(s), both singular and plural; also, transient voltage surge suppression.

D. Submittals
1. Product Data: For each type of product indicated. Include rated capacities, operating weights, electrical characteristics, furnished specialties, and accessories.
2. Field quality-control reports.
3. Operation and maintenance data.
4. Warranties: Sample of special warranties.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency, and marked for intended location and application.
2. Comply with IEEE C62.41.2 and test devices according to IEEE C62.45.
3. Comply with NEMA LS 1.
4. Comply with UL 1283, **as directed**, and UL 1449.
5. Comply with NFPA 70.

F. Project Conditions
1. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   a. Notify Owner no fewer than two days in advance of proposed electrical service interruptions.
   b. Do not proceed with interruption of electrical service without Owner's written permission.
2. Service Conditions: Rate TVSS devices for continuous operation under the following conditions unless otherwise indicated:
   a. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
   b. Operating Temperature: 30 to 120 deg F (0 to 50 deg C).
   c. Humidity: 0 to 85 percent, noncondensing.
   d. Altitude: Less than 20,000 feet (6090 m) above sea level.

G. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within Five years from date of Final Completion.

2. Special Warranty for Cord-Connected, Plug-in Surge Suppressors: Manufacturer's standard form in which manufacturer agrees to repair or replace electronic equipment connected to circuits protected by surge suppressors.

1.2 PRODUCTS

A. Service Entrance Suppressors
1. Surge Protection Devices:
   a. Non-modular.
   b. LED indicator lights for power and protection status.
   c. Audible alarm, with silencing switch, to indicate when protection has failed.
   d. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

   OR

   Surge Protection Devices:
   e. Comply with UL 1449.
   f. Modular design (with field-replaceable modules) **OR** Non-modular design, **as directed**.
   g. Fuses, rated at 200-kA interrupting capacity.
   h. Fabrication using bolted compression lugs for internal wiring.
   i. Integral disconnect switch (if a fused switch or circuit breaker is not provided for the TVSS in the panelboard and the TVSS will not have a direct bus bar connection).
   j. Redundant suppression circuits.
   k. Redundant replaceable modules.
   l. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.

      OR

      Arrangement with wire connections to phase buses, neutral bus, and ground bus.
   m. LED indicator lights for power and protection status.
   n. Audible alarm, with silencing switch, to indicate when protection has failed.
   o. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
   p. Four **OR** Six, **as directed**,-digit transient-event counter set to totalize transient surges.
2. Peak Single-Impulse Surge Current Rating: 320 kA per mode/640 kA **OR** 240 kA per mode/480 kA **OR** 160 kA per mode/320 kA, **as directed**, per phase.
3. Minimum single impulse current ratings, using 8-by-20-mic.sec waveform described in IEEE C62.41.2
   a. Line to Neutral: 70,000 A.
   b. Line to Ground: 70,000 A.
   c. Neutral to Ground: 50,000 A.
4. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 V **OR** 208Y/120 V **OR** 600Y/347 V, **as directed**, 3-phase, 4-wire circuits shall be as follows:
   a. Line to Neutral: 800 V for 480Y/277 V **OR** 400 V for 208Y/120 V **OR** 1200 V for 600Y/347 V, **as directed**.
   b. Line to Ground: 800 V for 480Y/277 V **OR** 400 V for 208Y/120 V **OR** 1200 V for 600Y/347 V, **as directed**.
   c. Neutral to Ground: 800 V for 480Y/277 V **OR** 400 V for 208Y/120 V **OR** 1200 V for 600Y/347 V, **as directed**.

   OR

   Protection modes and UL 1449 SVR for 240/120 V, single-phase, 3-wire circuits shall be as follows:

a. Line to Neutral: 400 V.
b. Line to Ground: 400 V.
c. Neutral to Ground: 400 V.

OR

Protection modes and UL 1449 SVR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:

a. Line to Neutral: 400 V, 800 V from high leg.
b. Line to Ground: 400 V.
c. Neutral to Ground: 400 V.

OR

Protection modes and UL 1449 SVR for 240 V, 480 V, or 600 V, 3-phase, 3-wire, delta circuits shall be as follows:

a. Line to Line: 2000 V for 480 V **OR** 1000 V for 240 V **OR** 2500 V for 600 V, **as directed**.
b. Line to Ground: 2000 V for 480 V **OR** 1000 V for 240 V **OR** 2500 V for 600 V, **as directed**.

B. Panelboard Suppressors

1. Surge Protection Devices:
   a. Non-modular.
   b. LED indicator lights for power and protection status.
   c. Audible alarm, with silencing switch, to indicate when protection has failed.
   d. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

   OR

   Surge Protection Devices:
   a. Comply with UL 1449.
   b. Modular design (with field-replaceable modules) **OR** Non-modular design, **as directed**.
   c. Short-circuit current rating complying with UL 1449, and matching or exceeding the panelboard short-circuit rating and redundant suppression circuits; with individually fused metal-oxide varistors.
   d. Fuses, rated at 200-kA interrupting capacity.
   e. Fabrication using bolted compression lugs for internal wiring.
   f. Integral disconnect switch (if a fused switch or circuit breaker is not provided for the TVSS in the panelboard and the TVSS will not have a direct bus bar connection).
   g. Redundant suppression circuits.
   h. Redundant replaceable modules.
   i. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
   j. LED indicator lights for power and protection status.
   k. Audible alarm, with silencing switch, to indicate when protection has failed.
   l. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
   m. Four **OR** Six, **as directed**,-digit transient-event counter set to totalize transient surges.
2. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA **OR** 120 kA per mode/240 kA **OR** 80 kA per mode/160 kA, **as directed**, per phase.
3. Minimum single impulse current ratings, using 8-by-20-mic.sec waveform described in IEEE C62.41.2:
   a. Line to Neutral: 70,000 A.
   b. Line to Ground: 70,000 A.
   c. Neutral to Ground: 50,000 A.
4. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 V **OR** 208Y/120 V **OR** 600Y/347 V, **as directed**, 3-phase, 4-wire circuits shall be as follows:
   a. Line to Neutral: 800 V for 480Y/277 V **OR** 400 V for 208Y/120 V **OR** 1200 V for 600Y/347 V, **as directed**.

b. Line to Ground: 800 V for 480Y/277 V **OR** 400 V for 208Y/120 V **OR** 1200 V for 600Y/347 V, **as directed**.
c. Neutral to Ground: 800 V for 480Y/277 V **OR** 400 V for 208Y/120 V **OR** 1200 V for 600Y/347 V, **as directed**.

OR

Protection modes and UL 1449 SVR for 240/120-V, single-phase, 3-wire circuits shall be as follows:
a. Line to Neutral: 400 V.
b. Line to Ground: 400 V.
c. Neutral to Ground: 400 V.

OR

Protection modes and UL 1449 SVR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:
a. Line to Neutral: 400 V, 800 V from high leg.
b. Line to Ground: 400 V.
c. Neutral to Ground: 400 V.

OR

Protection modes and UL 1449 SVR for 240 V, 480 V, or 600 V, 3-phase, 3-wire, delta circuits shall be as follows:
a. Line to Line: 2000 V for 480 V **OR** 1000 V for 240 V **OR** 2500 V for 600 V, **as directed**.
b. Line to Ground: 1500 V for 480 V **OR** 800 V for 240 V **OR** 2500 V for 600 V, **as directed**.

C. Enclosures
1. Indoor Enclosures: NEMA 250 Type 1 **OR** Type 12, **as directed**.
2. Outdoor Enclosures: NEMA 250 Type 3R **OR** Type 4 **OR** Type 4X, **as directed**.

1.3 EXECUTION

A. Installation
1. Install TVSS devices at service entrance on load side, with ground lead bonded to service entrance ground.
2. Install TVSS devices for panelboards and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
a. Provide multiple, 30 **OR** 60 **OR** 100, **as directed**,-A circuit breaker as a dedicated disconnecting means for TVSS unless otherwise indicated.

B. Field Quality Control
1. Perform tests and inspections.
a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
a. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, "Surge Arresters, Low-Voltage Surge Protection Devices" Section. Certify compliance with test parameters.
b. After installing TVSS devices but before electrical circuitry has been energized, test for compliance with requirements.
c. Complete startup checks according to manufacturer's written instructions.
3. TVSS device will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

C. Startup Service

a. Do not energize or connect service entrance equipment **OR** panelboards **OR** control terminals **OR** data terminals, **as directed**, to their sources until TVSS devices are installed and connected.
b. Do not perform insulation resistance tests of the distribution wiring equipment with the TVSS installed. Disconnect before conducting insulation resistance tests, and reconnect immediately after the testing is over.

D. Demonstration
a. Train Owner's maintenance personnel to maintain TVSS devices.

END OF SECTION 26 43 13 00

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Task	Specification	Specification Description
26 51 13 00	02 84 16 00a	Interior Lighting
26 51 16 00	02 84 16 00a	Interior Lighting
26 51 19 00	02 84 16 00a	Interior Lighting
26 51 23 00	02 84 16 00a	Interior Lighting
26 51 33 00	02 84 16 00	Removal of Fluorescent Light Ballasts/Capacitors and Fluorescent Light Tubes
26 51 33 00	02 84 16 00a	Interior Lighting
26 51 33 00	02 84 16 00b	Exterior Lighting
26 52 13 16	02 84 16 00a	Interior Lighting
26 55 13 00	01 22 16 00	No Specification Required
26 55 13 00	02 84 16 00b	Exterior Lighting
26 55 16 00	02 84 16 00a	Interior Lighting
26 55 16 00	02 84 16 00b	Exterior Lighting
26 55 29 00	02 84 16 00b	Exterior Lighting
26 55 53 11	02 84 16 00b	Exterior Lighting

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SECTION 26 55 61 00 - STAGE LIGHTING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for stage lighting. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Dimmer racks.
b. Control console and control devices.
c. Lighting fixtures and accessories.
d. Distribution components.

C. Performance Requirements
1. Seismic Performance: Dimmer racks shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event," **as directed**.

D. Submittals
1. Product Data: For each type of product indicated.
2. Seismic Qualification Certificates: For <**Insert equipment,**> accessories, and components, from manufacturer.
3. Field quality-control reports.
4. Operation and maintenance data.
5. Software and Firmware Operational Documentation.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NECA 1.
3. Comply with NFPA 70.

F. Software Service Agreement (if allowed)
1. Technical Support: Beginning with Final Completion, provide software support for two years.
2. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Final Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
a. Provide 30 days' notice to the Owner to allow scheduling and access to system and to allow the Owner to upgrade computer equipment if necessary.

1.2 PRODUCTS

A. Plug Connectors
1. Pin Type: USITT S3, two-pole, three-wire, 20-A.
2. Twist-Locking Type: NEMA WD 6, two-pole, three-wire, 20-A.

B. Lighting Fixtures And Accessories
1. General:
a. Comply with UL 1573 and listed and labeled by an NRTL.
b. Fixtures: Equipped with pigtail, yoke with pipe clamp, safety cable for batten mounting, and filter holder.
c. Metal Parts: Free of burrs, sharp corners, and edges.
d. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
e. Fixture Doors and Their Internal Access: Smooth operating, free of light leakage under operating conditions, and arranged to permit relamping without use of tools. Doors, lenses, diffusers, and other pieces arranged to prevent accidental falling during relamping and when secured in operating position.
f. Pigtail: Factory wired, 36-inch- (900-mm-) long, three-wire cord and plug connector assembly with cord encased in woven fiberglass or silicone tubing.
g. Lamp Sockets: Relampable without disturbing alignment or focus adjustment.
h. Fixture Ventilation Openings: Baffled against light leaks.
i. Fixture Operating Controls and Handles: Thermally insulated.
j. Lenses: Borosilicate glass in silicone mountings.
k. Framing Shutters: Stainless steel, four way; with each blade in a separate plane under adjustable tension mounting. Blades adjust plus or minus 30 degrees of rotation in gate, for 120-degree-minimum total angular rotation between adjacent blades.
l. Color Filter Frame Holder: Attached to front of fixture.
m. Fixture Yoke: Rigid metal, arranged for vertical aiming of unit and equipped with T-bolt or hand screw to lock alignment.
2. Ellipsoidal Spotlights: Fixtures with an elliptical reflector mounted in a fixed relationship to the lamp. Light shall be projected through a gate where the beam is shaped by using shutters, a gobo, or an iris. The shaped beam shall then be focused by a system of lenses.
a. Tag: ES-1:
1) Lamp: 1000 W Q1000/4CL, ANSI FEL.
2) Pattern Holders: Three for each fixture, with framing shutters.
3) Color Frame: Black, metal.
4) Minimum Cosine Illumination Performance Ratings When Operated with ANSI C78 Series, FEL Lamp:
a) 171,000 beam candlepower at 20-degree field angle.
b) 48,000 beam candlepower at 40-degree field angle.
3. Zoom Ellipsoidal Spotlights: Fixtures with an elliptical reflector mounted in an adjustable relationship to the lamp. Light shall be projected through a gate where the beam is shaped by using shutters, a gobo, or an iris. The shaped beam shall then be focused by a system of lenses.
a. Tag: ZES-1:
1) Lamp: 1000 W Q1000/4CL, ANSI FEL.
2) Pattern Holders: Three for each fixture, with framing shutters.
3) Operator adjustable from 25- to 50-degree field angle.
4) Field-angle adjustment scale label on instrument housing for field reference.
5) Minimum Cosine Illumination Performance Rating When Operated with ANSI C78 Series, FEL Lamp: 82,000 beam candlepower at 35-degree field angle.
4. Fresnel Lens Spotlights:
a. Die-cast extruded-aluminum housing, with hinged front for relamping.
b. Tag: FLS-1.
1) Lamp: 1000 W Q1000T7/4CL, ANSI EGT.
2) Lens: 6 inches (152 mm).
3) Illumination Performance Rating When Operated with ANSI C78 Series, EGT Lamp:
a) 175,000 beam candlepower at 12.5-degree field angle in spot focus.
b) 12,000 beam candlepower at 74.6-degree field angle in flood focus.
4) Barn Doors: Two 4-leaf rotatable metal flaps for every three fixtures.
5. Follow Spotlights:

a. Tag: FS-1:
   1) Lamp: Metal halide, G22 medium bi-post, CRI: 90, color: 6000 K, life: 750 hours, HMI 575 W/GS 95 V.
   2) Adjustable lenses in metal housing.
   3) Lamp: Quartz-projector type, Adjustable, underslung base stand mounted on 3-inch (75-mm), locking-type, rubber-tired, ball-bearing casters.
   4) Adjustable lamp holder and socket assembly with precision tuning adjustment; relampable without tools.
   5) Three-leaf, full-range mechanical dimmer.
   6) Adjustable iris and framing shutters.
   7) Automatic color boom.
   8) Removable power cable, 25 feet (8 m) long.
   9) Iris Open, Spot-Focus Performance: 800,000, **as directed**, beam candlepower at 7.2, **as directed**,-degree field angle.
   10) Iris Open, Flood-Focus Performance: 330,000, **as directed**, beam candlepower at 12.2, **as directed**,-degree field angle.

6. PAR Lamp Holders:
   a. Tag: PLH-1:
      1) Lamp: 300 W PAR 38.
      2) Housing: Steel or aluminum, flat black color, **as directed**, with porcelain-plated shell socket.
      3) Barn Doors: Two 4-leaf rotatable metal flaps for every three fixtures.
   b. Tag: <**Insert drawing designation**>:
      1) Lamp: 575 W tungsten halogen, 90 GLA 575 W, 230 V, color: 3200 K, ANSI GKV.
      2) Housing: Steel or aluminum, with porcelain-plated shell socket and color frame, **as directed**.
      3) Barn Doors: Two 4-leaf rotatable metal flaps for every three fixtures.
      4) With Lens Holder and Replaceable Lenses:
         a) <Insert drawing designation>: Very narrow spot.
         b) <Insert drawing designation>: Narrow spot.
         c) <Insert drawing designation>: Medium flood.
         d) <Insert drawing designation>: Wide flood.
         e) <Insert drawing designation>: Very wide.
      5) Motorized **OR** Manual, **as directed**, color wheel.
7. Borderlight Units: Compartmented, three-circuit striplight with nine 150-W, PAR 38/SP **OR** 150-W, PAR 38/FL **OR** 250-W, PAR 38/SP **OR** 150-W, R40/FL, **as directed**, lamps in porcelain sockets and steel sheet housing, 90 inches (2286 mm) long. Compartments shall be in line and wired on two **OR** three **OR** four, **as directed**, alternate circuits, each producing a different color.
   a. Front Door: Spring loaded; designed to hold either filter frames or color roundels.
   b. Color Roundels: One for each lamp; alternating red, blue, and clear, **as directed**.
      1) Additional Roundels: <**Insert number**> amber and <**Insert number**> green.
   c. Hanger: Adjustable, steel-strap type equipped at each end with pipe clamp and safety cable for suspension from a batten.
8. Cyclorama Lights: Suitable for lighting cycloramas from above.
   a. Tag: CL-1:
      1) Lamp: 1000 W Q1000T3/1CL, ANSI FFT.
      2) Housing: Aluminum or steel, **as directed**, flat black color, **as directed**, with color frame, **as directed**.
9. Black Lights: Portable, producing a wash of UV light for special effects.
   a. Tag: BL-1:
      1) Lamp: 250 W blacklight flood, H37KB-250, with integral filter to eliminate far-UV effect while maximizing the near-UV effect.
      2) Housing: Steel or aluminum, **as directed**, flat black color, **as directed**, with carry handle.
      3) C-clamp for using on light pipe.
10. Moving Lights:

a. Tag: ML-1:
   1) General: 700-W, 120-V, metal halide, motorized remote-controlled lighting instrument; NRTL listed.
   2) Lamp: Short-arc metal halide, 14,500 lumens; color temperature of 5600 K, CRI of 80.
   3) Color System: Three-filter CYM (cyan, yellow, magenta) cross-fading mechanism, and 11 standard colors on a fixed wheel.
   4) Optics: Zoom optics with continuously variable field angle from 18.5 to 42 degrees, programmable over a timed range of 2 seconds to 20 minutes; with a mechanical iris for beam-size control. Variable beam focus to soften the edges of gobos and light beams. Zoom combined with iris can project a beam with a field angle of 8 degrees.
   5) Dimming: Coated glass dimmer wheel, with controls to provide smooth timed fades.
   6) Strobe for strobe lighting effects.
   7) Gobo: One rotating wheel with five rotatable wheel positions and one open position. One fixed gobo wheel with 11 pattern positions and one open position.
   8) Beam Orientation Control: Smooth pan and tilt using a three-phase stepper motor system. Pan, 540 degrees; tilt, 270 degrees at 0.3-degree repeatability on either axis.
   9) Control: ANSI E1.11 (USITT DMX512-A) protocol using five pin connectors.

C. Distribution Components
1. Connector Strip: Listed and labeled by an NRTL; factory-wired wireway and receptacle assembly.
   a. Wireway: Steel or extruded aluminum, with removable cover and nominal cross-section dimensions of 3 by 4-1/2 inches (75 by 115 mm).
   b. Accessories: Cable clamps, support cradles, and cable strain relief grips for each cable.
   c. Receptacles: Pigtail mounted, 18 inches (450 mm) long, with strain relief at wireway wall penetration.
      OR
      Receptacles: Flush mounted in wireway cover.
   d. Receptacle Wiring: For connecting to terminal blocks; with 125 deg C, crosslinked, PE-insulated, identification-labeled wire.
   e. Terminal Blocks: Molded-barrier type with screw lugs to suit supply conductors.
   f. Mounting Hardware: Furnished with each unit; permits surface, single-pipe-bracket, or double-pipe-bracket mounting.
   g. Finish: Semigloss or matte black.
2. Plug-in Boxes: Listed and labeled by an NRTL; factory-wired wireway and receptacle assembly, 24 inches (600 mm) long unless otherwise indicated; with the following features:
   a. Wireway: Steel or extruded aluminum, with removable cover and nominal cross-section dimensions of 3 by 4-1/2 inches (75 by 115 mm).
   b. Accessories: Cable clamps, support cradles, and cable strain relief grips for each cable.
   c. Receptacles: Pigtail mounted, 18 inches (450 mm) long, with strain relief at wireway wall penetration.
      OR
      Receptacles: Flush mounted in wireway cover.
   d. Receptacle Wiring: For connecting to terminal blocks; with 125 deg C, crosslinked, PE-insulated, identification-labeled wire.
   e. Terminal Blocks: Molded-barrier type with screw lugs to suit supply conductors.
   f. Surface or Grid Mounting: With accessories for surface mounting or with pipe-mounting accessory bracket.
   g. Recessed Mounting: With flanged cover suitable for recessed mounting in wall.
   h. Finish: Semigloss or matte black.
3. Gridiron Junction Boxes: Listed and labeled by an NRTL; factory wired with terminal strips and concentric knockouts on all sides.
   a. Terminal Blocks: Molded-barrier type with screw lugs to suit supply conductors.

b. Accessories: Cable clamps, support cradles, and cable strain relief grips for each cable, and brackets for surface or pipe mounting.
c. Finish: Semigloss or matte black.

4. Floor Pockets: Listed and labeled by an NRTL; flush-mounted, receptacle outlet assembly.
a. Box: 0.0598-inch (1.5-mm) steel sheet, 10 inches (250 mm) deep.
b. Cover Plate: Steel, cast iron, or cast aluminum with nonskid safety tread surface and self-closing, hinged door with cable notches.
c. Barrier for allowing installation of low-voltage control receptacle for console input or handheld remotes.

D. Wire And Cable

1. Building Wire in Raceways: Comply with requirements specified in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
2. Portable Power Cable: Listed and labeled by an NRTL; flexible stage and lighting power cable; Type SC, SCE, or SCT; 600 V; multiconductor; 60 deg C temperature rating.
3. Ethernet Cabling: Comply with requirements specified in Division 26 Section "Control-voltage Electrical Power Cables".
a. For 10/100BaseT, comply with provisions for UTP cable and hardware.
b. For 10Base-FL, comply with provisions for 50/125 **OR** 62.5/125, **as directed**,-micrometer, multimode, optical-fiber cable and hardware.
4. ANSI E1.11 (USITT DMX512-A) Control Cabling: Comply with requirements specified in Division 26 Section "Control-voltage Electrical Power Cables".
a. Standard Cable: NFPA 70, Type CM **OR** Type CMG, **as directed**.
1) Paired, low-capacitance computer cable for ANSI E1.11 (USITT DMX512-A) applications. Two pairs, twisted, No. 22 AWG **OR** No. 24 AWG, **as directed**, stranded, tinned-copper conductors.
2) PE insulation.
3) Inner Shield: 100 percent coverage, aluminum foil-polyester tape.
4) Outer Shield: 90 percent coverage, tinned-copper braid.
5) Outer Shield Drain Wire: Stranded, tinned copper.
6) PVC jacket.
7) Flame Resistance: Comply with UL 1581.
b. Plenum-Rated Cable: NFPA 70, Type CMP.
1) Paired, low-capacitance computer cable for ANSI E1.11 (USITT DMX512-A) applications. Two pairs, twisted, No. 22 AWG **OR** No. 24 AWG, **as directed**, stranded, tinned-copper conductors.
2) Insulation: Foam fluoridated ethylene propylene.
3) Inner Shield: 100 percent coverage, aluminum foil-polyester tape.
4) Outer Shield: 90 percent coverage, tinned-copper braid.
5) Outer Shield Drain Wire: Stranded, tinned copper.
6) Low-smoke PVC jacket.
7) Flame Resistance: Comply with NFPA 262.
5. Low-Voltage Control Cabling:
a. Control-Cable Conductors:
1) Class 1 Control Circuits: Stranded copper, Type THHN-THWN, in raceway; complying with UL 83.
OR
Class 1 Control Circuits: Stranded copper, Type THHN, in raceway; complying with UL 44.
2) Class 2 Control Circuits: Stranded copper, Type THHN-THWN, in raceway **OR** power-limited cable, concealed in building finishes **OR** power-limited tray cable, in cable tray, **as directed**; complying with UL 83.
OR
Class 2 Control Circuits: Stranded copper, Type THHN, in raceway **OR** power-limited cable, concealed in building finishes **OR** power-limited tray cable, in cable tray, **as directed**; complying with UL 44.

3) Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or Type TF; complying with UL 83.

b. Paired Cable: NFPA 70, Type CMG.
1) One pair, twisted, No. 16 AWG, stranded, tinned-copper conductors.
2) PVC insulation.
3) Unshielded.
4) PVC jacket.
5) Flame Resistance: Comply with UL 1581.

c. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
1) One pair, twisted, No. 16 AWG, stranded (19x29), tinned-copper conductors.
2) PVC insulation.
3) Unshielded.
4) PVC jacket.
5) Flame Resistance: Comply with NFPA 262.

d. Paired Cable: NFPA 70, Type CMG.
1) One pair, twisted, No. 18 AWG, stranded (19x30), tinned-copper conductors.
2) PVC insulation.
3) Unshielded.
4) PVC jacket.
5) Flame Resistance: Comply with UL 1581.

e. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
1) One pair, twisted, No. 18 AWG, stranded (19x30), tinned-copper conductors.
2) Fluorinated ethylene propylene insulation.
3) Unshielded.
4) Plastic jacket.
5) Flame Resistance: Comply with NFPA 262.

E. Lighting Control System

1. Description: Microprocessor-based modular system consisting of dimmer and control modules operated from remote-control stations and a control console.
   a. Comply with UL 508.
   b. Comply with USITT AMX192 **OR** ANSI E1.11 (USITT DMX512-A), **as directed**, for data transmission.
2. Dimmer Racks: Listed and labeled by an NRTL; dead-front, front-access, wall-mounted **OR** freestanding, **as directed**, rack for mounting modular dimmers; formed-steel or extruded-aluminum structural members; completely enclosed with steel or aluminum panels. Painted with manufacturer's standard corrosion-resistant primer and finish coats, and having the following features:
   a. Primary Circuit Breaker: Fault-current withstand rating of the rack; not less than 10,000 **OR** 50,000, **as directed**, A, symmetrical.
   b. Hinged, locking front door, with openings to allow air intake across the face of all dimmer modules.
   c. Individual rack sections shall not exceed 84 inches high by 25 inches deep by 30 inches wide (2134 mm high by 635 mm deep by 762 mm wide). Multisection racks shall be interconnected with busbars.
   d. For each module position, provide support rails and control-pin configurations, constructed for precise alignment of dimmer modules into power and signal connector sockets.
   e. Forced-air cooling of each rack for maintaining operating temperature at each dimmer, assuming full load, in ambient temperature not to exceed 40 deg C. Exhaust rates shall be variable, using temperature sensors and fan-speed control electronics. Individual control of multiple fans is acceptable in lieu of fan-speed control. Fan(s) shall start and stop automatically. Fan noise at full load shall be less than 3.1 sones.
   f. Each rack shall have an automatic air-temperature sensor to shut off all dimmers in the rack should the internal temperature rise above maximum safe operating limits. In an

overheat condition, the fan shall continue operating. When a safe operating temperature is restored, the system shall automatically reset to allow normal user control.

g. Fabricate and test dimmer racks to withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".

3. Dimmers: Modular solid-state units that operate smoothly over their operating ranges without audible lamp noise or radio-frequency interference at any setting. Modules shall be dead-front, draw-out type with floating line, load, and control sockets for smooth insertion and withdrawal; with load-side thermal-magnetic circuit breaker, speed-controlled cooling fan, and overtemperature sensor.
   a. Non-Dim Units: On-off relay control only. Capable of serving inductive loads such as motors or high-intensity-discharge fixtures.
   b. Surge Protection: Modules shall withstand power-line surges of 6000 V/3000 A according to IEEE C62.41.1 and IEEE C62.41.2.
   c. Filter each dimmed circuit to provide a minimum 350-mic.sec., current-rise time at a 90-degree conduction angle at 50 percent of rated dimmer capacity. At any load within rating, rate of current rise shall not exceed 30 mA/mic.sec., measured from 10 to 90 percent of load current waveform.
4. Control System: Microprocessor-based control system, ANSI E1.11 (USITT DMX512-A) protocol, with a nonvolatile system memory to adjust dimmer channel settings for different scenes, to patch dimmers to channels, and to manually or automatically change dimmer settings from one preset scene to another.
   a. Control shall support Ethernet-based LAN at every control device.
   b. Provide means to create and monitor show data on a PC using software by console manufacturer. Software shall be capable of the following:
      1) Creating show and providing for use of USITT show files.
      2) Playing back show in a console-simulation mode.
      3) Accessing all remote-control stations associated with the console and control system.
      4) Providing standard Ethernet connection between the console control system and the PC.
   c. Display the following system status information on a color, 17-inch (430-mm) LCD monitor associated with the control console:
      1) Current channel intensities.
      2) Cue information.
      3) Monitor.
   d. Moving Lights: Include a standard control library, a program patch specific to fixture(s) provided, and selective programming with ANSI E1-11 (USITT DMX512-A) addressing of fade, focus points, beam, image, color, <**Insert attributes**> and position.
5. Control Console: Tabletop unit with manual and computer-based programming controls, memory units, indicating devices, and the following features:
   a. Servicing access through hinged top panel.
   b. Grand-master level control.
   c. Blackout switch.
   d. 12 submaster level controls with overlapping pile-on performance.
      OR
      24 submaster level controls with overlapping pile-on performance.
   e. Bump buttons for momentary control of channels or submasters, one for each submaster level control.
   f. Two cross-fade controls for split dipless fade between scenes, each with its own fade progress indicator.
   g. One set of scene level controls for each scene when used in two-scene preset mode. Second set of scene level controls to allow setting levels into memory for expanded single scenes when used in multiple single-channel scene mode. Each set shall have same quantity of scene level controls as is used for submaster level controls.
   h. Multibutton keypad for programming in multiscene memory mode.

i. Fade time control for assigning fade time to cues, with individual cue adjustment from one second to five minutes, minimum.
j. Light-emitting diode **OR** LCD **OR** Computer monitor cathode-ray tube, **as directed**, with associated display controls, for displaying operating menus and memory readout.
k. Controls for setting levels into memory.
l. Cord and connector for connecting console to outlets for console power and control.

6. System Operation: Selectable between multichannel two-scene preset and four-channel single-scene memory. Console features include electronic patching of control signals for up to 512 dimmers and off-line data storage using internal, 3-1/2-inch (90-mm) disk-drive unit. Operational capability includes the following:
   a. Live and blind programming.
   b. Special effects programmability for automatic operation of lights in pulsating, sequential dimming and brightening, and other special operating modes. Special effects menu displays operator guidance for programming and individual step levels.
   c. Signal from fire-alarm control panel that automatically brings selected circuits to fully on or fully bright condition, overriding normal dimming and on-off controls.
   d. Inserting cues between designated cues without renumbering.
   e. Out-of-sequence playback of cues.
   f. Controlling houselights and stage lights from console by assigning their dimmers or non-dim on-off controls to a channel.
   g. Retaining programmed cues in memory for minimum of one year after power outage.
   h. Automatic sequential execution of programmed cues.
   i. Printing cues using parallel or serial printer port, cable, and printer. Cable and printer are not included with this system.
7. PC: Standard, unmodified, with accessories and peripherals that are configured to install and run control-console manufacturer's written requirements, but not less than the following:
   a. CPU operating speed shall be at least 1.6 GHz.
   b. Memory: 1024 MB.
   c. Serial Ports: Provide two for general use.
   d. Parallel Port: Enhanced.
   e. LAN Adapter: 10/100/1000 Mbps, internal network interface card.
   f. Three USB 2.0 ports.
   g. Sound Card: For playback and recording of digital WAV sound files that are associated with audible warning and alarm functions.
   h. Color Monitor: Not less than 17 inches (430 mm), with a minimum resolution of 1280 by 1024 pixels, noninterlaced, and a maximum dot pitch of 0.28 mm. Video card shall support at least 256 colors at a resolution of 1280 by 1024 pixels at a minimum refresh rate of 70 Hz.
   i. Keyboard: With a minimum of 64 characters; standard ASCII character set based on ANSI INCITS 154 (formerly ANSI X3.154).
   j. Mouse: Standard, compatible with installed software.
   k. Disk storage shall include the following, each with appropriate controller:
      1) Minimum 60 GB hard disk, 5400 rpm.
      2) Floppy Disk Drive: High density, 3-1/2-inch (90-mm) size.
      3) <**Insert disk drives**>.
   l. CD-ROM Drive: 24x/10x/24x CD-RW/8x DVD combination.
8. Console Power and Control Outlets: Multiple receptacles matched to connector on console connector cord.
9. House Lighting Control Station: Architectural-type, multichannel, remote-dimmer-control station with the following features:
   a. System controls designated houselights, stage lights, and other lights.
   b. Stage lighting controls compatible with dimming and control system.
   c. Flush mounting.
   d. Brushed-aluminum wall plate.
   e. Five **OR** Six, **as directed**, channels, each with slider potentiometer control.

f. Master-slider potentiometer that controls lights on all channels proportionally from completely dimmed to degree of brightness that corresponds to individual slider positions.
g. Fully on switch that turns all channels on at full brightness regardless of slider position.
h. Take-control/off switch that places station in control of channels and sets lighting to levels dictated by channel and master-slider controls.
i. Legend on face of wall plate that identifies items as "House Lighting Control Station" and identifies functions of each slider and switch position, with slider positions individually graduated from zero to 10.
j. Illuminated push buttons for activating preset scenes of house lighting and labeled "Entry" **OR** "Panic" **OR** "Entry" and "Panic," **as directed**.
k. Flush wall mounted unless otherwise indicated.

10. Entry Station: Push button activates or deactivates indicating light and presets scene of house lighting control system.
    a. Light-emitting-diode indicating light illuminates when preset command is executed.
    b. Labeled "Entry."
    c. Flush wall mounted unless otherwise indicated.
11. Key-Entry Station: Key-operated switch controls station to activate or deactivate indicating light and presets scene of lighting control system.
    a. Light-emitting-diode indicating light illuminates when preset command is executed.
    b. Labeled "Entry."
    c. Flush wall mounted unless otherwise indicated.
12. Emergency Lighting Control Station: Key-operated, **as directed**, push button activates indicating light and brings selected dimmers to fully bright condition, i.e., the "Panic" preset. Operating push button a second time returns dimmers to previous setting.
    a. Emergency mode indicating light.
    b. Labeled "Emergency Lights."
    c. Flush wall mounted unless otherwise indicated.

F. Rigging Components
1. Pipe Clamps: Malleable iron, suitable for clamping fixtures or items to pipe from 3/4 to 2 inches (20 to 51 mm) in OD. Arranged for horizontal rotation of yoke for aiming; equipped with T-bolt to lock alignment.
2. Safety Cables: Heavy-duty, flexible steel; 30-inch (762-mm) nominal length, with spring clip at one end and steel ring at the other end.
3. Cable Grips: Stainless **OR** Galvanized, **as directed**, steel; basket-weave type for supporting stage cables.

1.3 EXECUTION

A. Installation
1. Set permanently mounted items level, plumb, and square with ceilings and walls.
2. Indicated mounting heights are to bottom of unit for suspended items and to center of unit for wall-mounted items.
3. Mount and connect fixtures, and install and connect distribution devices.
    a. If arrangement is not indicated, install so each fixture, dimmer, house lighting circuit, control channel, and outlet circuit can be operated, and complete system demonstrated, in all operating modes.
    b. Install safety cables secured to stage rigging or gridiron for all pipe-mounted electrical fixtures and equipment.
4. Dimmer Rack Mounting: Install and anchor dimmer racks level on 4-inch- (100-mm-) high concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
    a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.

b. For dimmer racks, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
d. Install anchor bolts to elevations required for proper attachment to dimmer racks.

5. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".

B. Wiring
1. Power Wiring:
a. Install wiring as specified in Division 26 Section "Low-voltage Electrical Power Conductors And Cables" for hardwired connections. Install wiring in raceways except cable and plug connections.
b. Install power wiring with a separate neutral for each output circuit from main dimmer and for each house and stage lighting circuit.
2. Signaling, Remote-Control, and Power-Limited Circuits:
a. Comply with requirements specified in Division 26 Section "Control-voltage Electrical Power Cables" for installation of wiring. Install wiring in raceways except cable and plug connections.
b. Comply with the following unless otherwise indicated:
1) Size conductors according to lighting control device manufacturer's written instructions.
2) Select cable insulation, shielding, drain wire, and jacket complying with lighting control device manufacturer's written instructions.
3) Install circuits to eliminate radio-frequency interference and electromagnetic interference.
c. Remote-control circuits associated with emergency lighting control shall be installed complying with Class 1 Circuit standards in NFPA 70.
3. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points.
4. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes and in terminal cabinets and equipment enclosures.
5. Remove wall plates and protect devices and assemblies during painting.
6. Support lighting fixtures, distribution components, and accessories as specified in Division 26 Section "Hangers And Supports For Electrical Systems". Equip all pipe-mounted equipment with safety cables that are secured to supporting pipe.
7. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".

C. Identification
1. Identify components, power, and control wiring according to Division 26 Section "Identification For Electrical Systems".
2. Label each fixture, lighting outlet, distribution device, and dimmer module with unique designation. Labels on elevated components shall be readable from the floor.

D. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
a. Schedule visual and mechanical inspections and electrical tests with at least seven days' advance notice.
b. Visual and Mechanical Tests and Inspections:
1) Inspect each fixture, outlet, module, control, and device for defects, finish failure, corrosion, physical damage, labeling by an NRTL, and nameplate.
2) Exercise and perform operational tests on mechanical parts and operable devices according to manufacturer's written instructions.
3) Check tightness of electrical connections with torque wrench.

4) Verify proper protective device settings, fuse types, and ratings.
5) Record results of tests and inspections.

c. Electrical Tests: Perform tests according to manufacturer's written instructions.
1) Continuity tests of circuits.
2) Operational Tests: Connect each outlet to a fixture and a dimmer output circuit so each dimmer module, dimmer control and output circuit, outlet, and fixture in a typical operating mode will be sequentially tested. Set and operate controls to demonstrate fixtures, outlets, dimmers, and controls in a sequence that cues and reproduces actual operating functions for a typical system of the size and scope installed. Include operation and control of houselights and stage lights from each control location and station including optional plug-in, control-console outlet locations. Record fixture and outlet assignments, control settings, operations, cues, and observations of performance.

d. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible organization and individual.

3. Stage lighting will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.
a. Prepare a schedule of lighting outlets by number; indicate circuits, dimmers, connected fixtures, and control-channel assignments. Prepare a schedule of control settings and circuit assignments for house control channels. Prepare written reports of tests and observations. Report defective materials, workmanship, and unsatisfactory test results. Include records of repairs and adjustments made.

E. Adjusting
1. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

END OF SECTION 26 55 61 00

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SECTION 26 55 68 00 - SPORTS LIGHTING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for exterior athletic lighting. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes lighting for the following outdoor sports venues:
a. Baseball fields.
b. Softball fields.
c. Football fields.
d. Soccer fields.
e. Outdoor tennis courts.

C. Definitions
1. CV: Coefficient of variation; a statistical measure of the weighted average of all relevant illumination values for the playing area, expressed as the ratio of the standard deviation for all illuminance values to the mean illuminance value.
2. Delegated-Design Submittals: Documents, including drawings, calculations, and material and product specifications prepared as a responsibility of Contractor to obtain acceptance by the Owner and authorities having jurisdiction.
3. Illuminance: The metric most commonly used to evaluate lighting systems. It is the density of luminous flux, or flow of light, reaching a surface divided by the area of that surface.
a. Horizontal Illuminance: Measurement in foot-candles (lux), on a horizontal surface 36 inches (914 mm) above ground unless otherwise indicated.
b. Target Illuminance: Average maintained illuminance level, calculated by multiplying initial illuminance by LLF.
c. Vertical Illuminance: Measurement in foot-candles (lux), in two **OR** four, **as directed**, directions on a vertical surface, at an elevation coinciding with plane height of horizontal measurements.
4. LC: Lighting Certified.
5. Light Trespass: Light spill into areas and properties outside the playing areas, which is either annoying or unwanted.
6. LLD: Lamp lumen depreciation, which is the decrease in lamp output as the lamp ages.
7. LLF: Light loss factor, which is the product of all factors that contribute to light loss in the system.
8. Luminaire: Complete lighting fixture, including ballast housing if integral.
9. UG: Uniformity gradient; the rate of change of illuminance on the playing field, expressed as a ratio between the illuminances of adjacent measuring points on a uniform grid.

D. Performance Requirements
1. Facility Type: Professional **OR** College **OR** Semiprofessional **OR** Sports club **OR** Amateur league **OR** High school **OR** Training facility **OR** Elementary school **OR** Recreational or social facility, **as directed**.
2. Illumination Criteria:
a. Minimum average target illuminance level for each lighted area for each sports venue and for the indicated class of play according to IESNA RP-6.
b. CV and maximum-to-minimum uniformity ratios for each lighted area equal to or less than those listed in IESNA RP-6 for the indicated class of play.
c. UG levels within each lighted area equal to or less than those listed in IESNA RP-6 for the indicated speed of sport.

3. Illumination Criteria:
   a. Minimum Average Target Illumination: <**Insert value**>.
   b. CV: <**Insert value**>.
   c. Maximum-to-Minimum Uniformity Ratio: <**Insert value**>.
   d. UG Level: <**Insert value**>.
4. Illumination Calculations: Computer-analyzed point method complying with IESNA RP-6 to optimize selection, location, and aiming of luminaires.
   a. Grid Pattern Dimensions: For playing areas of each sport and areas of concern for spill-light control, correlate and reference calculated parameters to the grid areas. Each grid point represents the center of the grid area defined by the length and width of the grid spacing.
   b. Spill-Light Control: Minimize spill light for each playing area on adjacent and nearby areas.
      1) Prevent light trespass on properties near Project as defined by <**Insert name(s) of authorities having jurisdiction**>.
      2) For areas indicated on Drawings as "spill-light critical," limit the level of illuminance directed into the area from any luminaire or group of luminaires, and measured 36 inches (914 mm) above grade to the following:
         a) Maximum Horizontal Illuminance: 0.25 fc (2.7 lux) **OR** 0.5 fc (5.4 lux) **OR** 0.75 fc (8.1 lux), **as directed**.
         b) Maximum Vertical Illuminance from the Direction of the Greatest Contribution of Light: 1.0 fc (10.8 lux) **OR** 2.0 fc (21.5 lux) **OR** 3.0 fc (32.3 lux), **as directed**.
      3) Calculate the horizontal and vertical illuminance due to spill light for points spaced 20 feet (6 m) apart in areas indicated on Drawings as "spill-light critical," to ensure that design meets the above limits.
   c. Glare Control: Design illumination for each playing area to minimize direct glare in adjacent and nearby areas.
      1) Design source intensity of luminaires that may be observed at an elevation of 60 inches (1524 mm) above finished grade from nearby properties to be less than 12,000 **OR** 20,000 **OR** 30,000, **as directed**, candela when so observed.
      2) Design source intensity of luminaires that may be observed at an elevation of 60 inches (1524 mm) above finished grade from designated "spill-light critical" areas to be less than 12,000 **OR** 20,000 **OR** 30,000, **as directed**, candela when so observed.
   d. Determine LLF according to IESNA RP-6 and manufacturer's test data.
      1) Use LLD at 100 percent of rated lamp life. LLF shall be applied to initial illumination to ensure that target illumination is achieved at 100 percent of lamp life and shall include consideration of field factor.
      2) LLF shall not be higher than 70 percent, and may be lower when determined by manufacturer after application of the ballast output and optical system output according to IESNA RP-6.
   e. Luminaire Mounting Height: Comply with IESNA RP-6, with consideration for requirements to minimize spill light and glare.
   f. Luminaire Placement: Luminaire clusters shall be outside the glare zones defined by IESNA RP-6.
5. Baseball Fields:
   a. IESNA RP-6, Class of Play: I **OR** II **OR** III **OR** IV, **as directed**.
   b. Speed of Sport: Fast **OR** Moderate **OR** Slow, **as directed**.
   c. Grid Pattern Dimensions: 30 by 30 feet (9 by 9 m).
6. Softball Fields:
   a. IESNA RP-6, Class of Play: I **OR** II **OR** III **OR** IV, **as directed**.
   b. Speed of Sport: Fast **OR** Moderate **OR** Slow, **as directed**.
   c. Grid Pattern Dimensions: 20 by 20 feet (6 by 6 m).
7. Football Fields:
   a. IESNA RP-6, Class of Play: I **OR** II **OR** III **OR** IV, **as directed**.

b. Speed of Sport: Fast **OR** Moderate **OR** Slow, **as directed**.
c. Grid Pattern Dimensions: 30 by 30 feet (9 by 9 m).

8. Soccer Fields:
   a. IESNA RP-6, Class of Play: I **OR** II **OR** III **OR** IV, **as directed**.
   b. Speed of Sport: Fast **OR** Moderate **OR** Slow, **as directed**.
   c. Grid Pattern Dimensions: 30 by 30 feet (9 by 9 m).
9. Outdoor Tennis Courts:
   a. IESNA RP-6, Class of Play: I **OR** II **OR** III **OR** IV, **as directed**.
   b. Speed of Sport: Fast **OR** Moderate **OR** Slow, **as directed**.
   c. Grid Pattern Dimensions: 10 by 10 feet (3 by 3 m).
10. Egress Lighting: In case of power failure, provide a minimum of 1.0-fc (10.8-lux) illumination, within 30 seconds, measured at grade in spectator and spectator egress areas.
    a. Duration of emergency illumination shall be not less than 15 minutes.
    b. Momentary Power Interruptions: Provide emergency illumination immediately following restoration of power to the lighting circuits. Emergency illumination shall automatically extinguish after 15 minutes.
11. Lighting Control: Manual, low voltage, or digital; providing the following functions, integrated into a single control station, with multiple subcontrol stations as indicated:
    a. Control Station: Key-operated master switch, manual push-button controls, and system status indicator lights. Test switch of egress lighting system, **as directed**.
    b. Light Levels: Two levels of control - 100/50 percent of minimum target illumination.
12. Electric Power Distribution Requirements:
    a. Electric Power: 208 **OR** 230 **OR** 480, **as directed**, V; three phase.
       1) Include roughing-in of service indicated for nonsports improvements on Project site.
       2) Balance load between phases. Install wiring to balance three phases at each support structure.
       3) Include required overcurrent protective devices and individual lighting control for each sports field or venue.
       4) Include indicated feeder capacity and panelboard provisions for future lighted sports field construction.
13. Maximum Total Load: <**Insert number**> A.
    a. Maximum Total Voltage Drop from Source to Load: 5 percent, including voltage drops in branch circuit, subfeeder, and feeder.
14. Seismic Performance: Luminaires, ballasts, and support structures shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
15. Life-Cycle Cost Criteria:
    a. Estimated life-cycle cost of lighting system for period of <**Insert number**> years based on the parameters below:
       1) Energy Cost: <**Insert value**> {Calculate energy costs by multiplying (number of luminaires) x (kilowatt demand per luminaire) x (power cost at $/kilowatts) x (number of annual usage hours) x (number of years)}.
       2) Lamp Replacement Cost: <**Insert value**> (Calculate replacement costs by multiplying (cost to replace a lamp) x (number of luminaires) x (number of relamps over the period of years used in calculating the energy cost)).
       3) General Maintenance: <**Insert value**> (Calculate maintenance costs by multiplying (number of repairs) x (cost per repair) over the life cycle).

       OR

       Life-Cycle Cost Criteria: <**Insert value**> (Calculate according to Federal Energy Management Program's "Building Life-Cycle Cost").

E. Submittals
   1. Product Data: For each type of lighting product indicated. Include the following:

a. Lamp life, output, and energy-efficiency data. Lamp data certified by NVLAP or NRTL; comply with IESNA LM-47.
b. Photometric data based on laboratory tests of each luminaire type, complete with lamps, ballasts, and accessories; comply with IESNA LM-5.
1) Photometric data shall be certified by a qualified independent testing agency.
OR
Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.

2. Delegated-Design Submittal: For exterior athletic lighting indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
a. Drawings and specifications for construction of lighting system.
b. Manufacturer's determination of LLF used in design calculations.
c. Lighting system design calculations for the following:
1) Target illuminance.
2) Point calculations of horizontal and vertical illuminance, CV, and UG at minimum grid size and area.
3) Point calculations of horizontal and vertical illuminance in indicated areas of concern for spill light.
4) Calculations of source intensity of luminaires observed at eye level from indicated properties near the playing fields.
d. Electrical system design calculations for the following:
1) Short-circuit current calculations for rating of panelboards.
2) Total connected and estimated peak-demand electrical load, in kilowatts, of lighting system.
3) Capacity of feeder **OR** service, **as directed**, required to supply lighting system.
e. Wiring requirements, including required conductors and cables and wiring methods.
f. Structural analysis data and calculations used for pole selection.
1) Manufacturer Wind-Load Strength Certification: Submit certification that selected total support system, including poles, complies with AASHTO LTS-4-M for location of Project.

3. Qualification Data: For qualified Installer, manufacturer, professional engineer, luminaire photometric data testing laboratory and field testing agency.
4. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.
a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Manufacturer Certificates: For support structures, including brackets, arms, appurtenances, bases, anchorages, and foundations, from manufacturer.
6. Welding certificates.
7. Field quality-control reports.
8. Operation and Maintenance Data: For sports lighting system components to include in emergency, operation, and maintenance manuals.
9. Warranty: Sample of special warranty.

F. Quality Assurance
1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Manufacturer Qualifications: Manufacturer's responsibilities include fabricating sports lighting and providing professional engineering services needed to assume engineering responsibility.

a. Engineering Responsibility: Preparation of delegated-design submittals and comprehensive engineering analysis by a qualified professional engineer who is additionally LC by the National Council on Qualifications for the Lighting Professions, **as directed**.

3. Luminaire Photometric Data Testing Laboratory: By manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
4. Luminaire Photometric Data Testing Laboratory: By an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL.
5. Field Testing Agency Qualifications: An independent testing agency that is accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products, or an NRTL as defined in 29 CFR 1910, with the experience and capability to conduct field testing according to IESNA LM-5.

   OR

   Field Testing Agency Qualifications: A qualified independent professional engineer not associated with Contractor or lighting equipment manufacturer, who is additionally LC by the National Council on Qualifications for the Lighting Professions, **as directed**.
6. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel" and AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
7. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of luminaires, lamps, and luminaire alignment products and to correct misalignment that occurs subsequent to successful acceptance tests. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, and unauthorized repairs and alterations from special warranty coverage.
   a. Luminaire Warranty: Luminaire and luminaire assembly (excluding fuses and lamps) shall be free from defects in materials and workmanship for a period of five years from date of Final Completion.
   b. Lamp Warranty:
      1) Replace lamps and fuses that fail within 12 months from date of Final Completion.
      2) Provide replacement lamps for lamps that fail within the second 12 months from date of Final Completion.
   c. Alignment Warranty: Accuracy of alignment of luminaires shall remain within specified illuminance uniformity ratios for a period of five years from date of successful completion of acceptance tests.
      1) Realign luminaires that become misaligned during the warranty period.
      2) Replace alignment products that fail within the warranty period.
      3) Verify successful realignment of luminaires by retesting as specified in "Field Quality Control" Article.

1.2 PRODUCTS

A. Luminaires, Lamps, And Ballasts

1. Luminaires: Listed and labeled, by an NRTL acceptable to authorities having jurisdiction, for compliance with UL 1598 for installation in wet locations.
   a. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without using tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent their accidental falling during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lens.
   b. Exposed Hardware: Stainless-steel latches, fasteners, and hinges.

c. Spill-Light Control Devices: Internal louvers and external baffles furnished by manufacturer and designed for secure attachment to specific luminaire.
d. Luminaires for tennis courts shall be bracket-mounted, full-cutoff type with integral ballasts.
e. Lamps for Tennis Court Luminaires: Metal halide, rated 1000 W.

2. Ballast Mounting: Grouped in cabinets, remote from **OR** At, **as directed**, location of associated luminaires unless otherwise indicated.

B. Support Structures

1. Support-Structure Wind-Load Strength: Poles and other support structures, brackets, arms, appurtenances, bases, anchorages, and foundations shall comply with AASHTO LTS-4-M and shall be certified by manufacturers to withstand winds up to 100 mph (160 km/h) without permanent deflection or whipping.
2. Support-Structure Seismic Strength: Poles or other support structures, brackets, arms, appurtenances, bases, anchorages, and foundations shall be designed to prevent separation of components or fracture of poles, luminaire supports, or pole foundations during a seismic event.
3. Mountings, Fasteners, and Appurtenances:
   a. Corrosion resistant, compatible with support components, and which shall not cause galvanic action at contact points.
      1) Steel Components: Hot-dip galvanized after fabrication, complying with ASTM A 123/A 123M.
      2) Mounting Hardware Fasteners: Hot-dip galvanized, complying with ASTM A 153/A 153M, or minimum 18-8 grade stainless steel.
   b. Accommodate attachments and wiring of other indicated systems.
4. Concrete for Pole Foundations: 3000-psi (20.7-MPa), 28-day minimum compressive strength. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-place Concrete".
5. Direct-buried steel structures or poles shall not be used.

C. Power Distribution And Control

1. Wiring Method for Feeders, Subfeeders, Branch Circuits, and Control Wiring: Underground nonmetallic raceway; No. 10 AWG minimum conductor size for power wiring.
2. Overhead-, pole-, or structure-supported wiring and transformers are **OR** are not, **as directed**, permitted.
3. Electrical Enclosures Exposed to Weather: NEMA 250, Type 3R enclosure constructed from stainless steel **OR** corrosion-resistant material, **as directed**, with hinged doors fitted with padlock hasps or lockable latches.

D. Surge Protection

1. Surge Protection: Comply with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits" and include surge suppressors with the following requirements:
   a. Panelboard type.
   b. Nonmodular, with digital indicator lights and one set of dry contacts, **as directed**.
   c. Peak Single-Impulse Surge Current Rating: <**Insert number**> kA per phase.

E. Pole And Base Protection

1. Pole Pads: Wraparound pad, with 4 inches (100 mm) of extra-firm polyfoam, 360-degree coverage of ground-mounted poles and supports, continuous hook-and-loop fastening, and not less than 72 inches (1820 mm) high.

1.3 EXECUTION

A. Installation

1. Use web fabric slings (not chain or cable) to raise and set structural members. Protect equipment during installation to prevent corrosion.
2. Install poles and other structural units level, plumb, and square.
3. Except for embedded structural members, grout void between pole base and foundation. Use nonshrinking or expanding concrete grout firmly packed in entire void space. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole. Nonshrink grout is specified in Division 05 Section "Metal Fabrications".
4. Install pole pads at all poles inside playing field boundaries and when located within 20 feet (6 m) of the field boundary.
5. Extend cast-in-place bolted base foundations 36 inches (914 mm) above grade, minimum.
6. Install protective pipe bollards on two **OR** three, **as directed**, sides of each embedded pole installed in paved areas. See Division 05 Section "Metal Fabrications" for pipe bollards.
7. Install controls and ballast housings in cabinets mounted on support structure at least 10 feet (3 m) above finished grade.

B. Field Quality Control
1. Perform tests, inspections, and analysis according to IESNA RP-6 and IESNA LM-5 where applicable.
2. Tests and Inspections:
   a. After installing sports lighting system and after electrical circuits have been energized, perform proof-of-performance field measurements and analysis for compliance with requirements.
   b. Playing and Other Designated Areas: Make field measurements at intersections of grids, dimensioned and located as specified in "Performance Requirements" Article and as described below:
      1) Baseball Fields: Measure at least 25 points of the infield and 87 points of the outfield. Extend the grid 15 feet (5 m) outside the foul lines, extending to outfield boundary or fence.
      2) Softball Fields: Measure at least 16 points of the infield and 48 points of the outfield. Extend the grid 15 feet (5 m) outside the foul lines, extending to outfield boundary.
      3) Football Fields: Lighted area is 180 by 360 feet (55 by 110 m). Measure at least 91 points.
      4) Soccer Fields: Lighted area is 210 by 370 feet (64 by 113 m). Measure at least 91 points.
      5) Tennis Courts: Measure at least 30 points for a double court.
   c. Make field measurements at established test points in areas of concern for spill light and glare.
   d. Perform analysis to demonstrate correlation of field measurements with specified illumination quality and quantity values and corresponding computer-generated values that were submitted with engineered design documents. Submit a report of the analysis. For computer-generated values, use manufacturer's lamp lumens that are adjusted to lamp age at time of field testing.
3. Correction of Illumination Deficiencies for Playing Areas: Make corrections to illumination quality or quantity, measured in field quality-control tests, that varies from specified illumination criteria by plus or minus 10 percent.
   a. Add or replace luminaires, or change mounting height, revise aiming, or install louvers, shields, or baffles.
   b. If luminaires are added or mounting height is changed, revise aiming and recalculate and modify or replace support structures if indicated.
   c. Do not replace luminaires with units of higher or lower wattage without the Owner's approval.
   d. Retest as specified above after repairs, adjustments, or replacements are made.
   e. Report results in writing.

4. Correction of Excessive Illumination in Spill-Light-Critical Areas: If measurements indicate that specified limits for spill light are exceeded, make corrections to illumination quantity, measured in field quality-control tests, that reduce levels to within specified maximum values.
   a. Replace luminaires, or change mounting heights, revise aiming, or install louvers, shields, or baffles.
   b. Obtain the Owner's approval to replace luminaires with units of higher or lower wattage.
   c. If mounting height is changed, revise aiming and recalculate and modify or replace support structures if indicated.
   d. Retest as specified above after repairs, adjustments, or replacements are made.
   e. Report results in writing.
5. Sports lighting will be considered defective if it does not pass tests and inspections.
6. Prepare test and inspection reports.

C. Demonstration
   1. Train the Owner's maintenance personnel to adjust, operate, and maintain exterior athletic lighting.

END OF SECTION 26 55 68 00

Task	Specification	Specification Description
26 56 13 00	01 22 16 00	No Specification Required
26 56 13 00	02 84 33 00	Overhead Electrical Distribution
26 56 13 00	02 84 16 00b	Exterior Lighting
26 56 18 00	02 84 16 00b	Exterior Lighting
26 56 19 00	02 84 16 00a	Interior Lighting
26 56 19 00	02 84 16 00b	Exterior Lighting
26 56 21 00	01 22 16 00	No Specification Required
26 56 21 00	02 84 33 00	Overhead Electrical Distribution
26 56 21 00	02 84 16 00b	Exterior Lighting

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Task	Specification	Specification Description
27 05 26 00	26 05 53 00a	Intercommunications and Program Systems
27 11 16 00	26 05 53 00a	Intercommunications and Program Systems

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SECTION 27 11 19 00 - LOOSE-TUBE GEL-FILLED FIBER OPTIC CABLES

GENERAL

Description Of Work

1. This specification covers the furnishing and installation of loose-tube gel-filled fiber optic cables. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

Shop Drawings And Samples

2. The following shall be submitted:
   a. Complete bill of materials.
   b. Drawings indicating the locations of all pull boxes with station numbers.
   c. Catalog data on all testing devices proposed for use plus certifications of accuracy, calibration, and traceability to standards of the National Institute for Standards and Testing.
   d. Cable pulling calculations for all conduit runs. Indicate on the submittal any additional pull boxes that are required, including station number and a written description, of the location.
   e. A cable pulling and splicing work plan shall be submitted a minimum of 45 days prior to the planned initiation of cable pulling. The pulling plan and pull tension calculations may be prepared by using a software program such as Pull-Planner 2000 by American Polywater Corporation. The cable pulling and splicing work plan must be approved a minimum of 15 days prior to pulling cable. Work plan shall include the following:
      1) Pull tension calculations
      2) Calculated amount of lubrication required
      3) Detailed description of pull operation methods for all conduit runs

Quality Assurance

3. All work described in this section shall meet or exceed the applicable provisions of the following documents:
   a. ANSI C8.471983, American National Standard for Polyolefin Insulated Thermoplastic Jacketed Communication Cables.
   b. EIA-455 (addendum 1 through 5) Standard Test Procedures for Fiber Optics, Cables, Transducers, Connecting and Terminating Devices.
   c. EIA-455-27A, Method of Measuring (Uncoated) Diameter of Optical Waveguide Fibers.
   d. EIA-455-28A, Method For Measuring Tensile Failure Point of Optical Waveguide Fibers.
   e. EIA-455-34, Interconnection Device Insertion Loss Test.
   f. EIA-455-89, Fiber Optic Cable Jacket Elongation and Tensile Strength.

Warranty

4. The Contractor shall provide an unconditional warranty on all installed cable for a minimum period of two (2) years.

PRODUCTS

Materials

5. Fiber Optic Cable - 24 strand
   a. Cable type: Outdoor Plant Stranded Loose-Tube, Gel-Filled Fiber Optic Cable, Corning Altos 024RW4-14101A20 or Lucent Lightpack 7D1X-024-BXD.
   b. Number of fibers: 24 fibers.
   c. Buffer Tubes: All optical fibers shall be placed inside a loose buffer tube. The optical cable shall contain three buffer tubes, numbered 1, 2, and 3. The tubes shall be color coded according to the table below:

Buffer Tube Number	Buffer Tube Color
1	Blue
2	Orange
3	Green

d. Each buffer tube shall contain 8 singlemode fibers. Each fiber shall be numbered and distinguishable by means of the color coding established in the main body of the specification.
e. The colors of the individual fibers shall be stable across the specified storage and operating temperature range and not subject to fading or smearing onto each other or into the gel filling material. Colors shall not cause fibers to stick together.
f. The fibers shall not adhere to the inside walls of the loose buffer tube. Buffer tubes shall be kink resistant within the specified minimum bend radius.
g. Filler may be included in the cable core composition to lend symmetry to the cable cross-section where needed.
h. A central anti-buckling member shall be included into the cable to prevent buckling of the cable. The anti-buckling member shall be composed of a glass reinforced plastic rod.
i. Each buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional nontoxic solvents.
j. Buffer tubes shall be stranded around a central member using the reverse oscillation, or "S-Z", stranding process.
k. The cable core shall contain a water-blocking material. The water blocking material shall be non-nutritive to fungus, electrically non-conductive and homogenous. It shall also be free from dirt and foreign matter and shall be readily removable with conventional nontoxic solvents.
l. Binders shall be applied with sufficient tension to secure the buffer tubes to the member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking and dialectic with low shrinkage.
m. Tensile strength shall be provided by a combination of high tensile strength dielectric yarns. The high tensile strength dielectric yarns shall be helically stranded evenly around the cable core.
n. The all-dielectric cable shall be sheathed with medium density polyethylene (MDPE). The minimum nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and water blocking material. The jacket or sheath shall be free of holes, splits, and blisters. The cable jacket shall contain no metallic elements and shall be of a consistent thickness.
o. The cable shall contain at least one ripcord under the sheath for easy sheath removal.

6. Fiber Optic Cable - 36 Strand
   a. Cable type: Outdoor Plant Stranded Loose-Tube, Gel-Filled Fiber Optic Cable, Corning Altos 036RW4-14101A20 or Lucent Lightpack 7D1X-036-BXD.
   b. Number of fibers: 36 fibers.
   c. Buffer Tubes: All optical fibers shall be placed inside a loose buffer tube. The optical cable shall contain three buffer tubes, numbered 1, 2, and 3. The tubes shall be color coded according to the table below:

Buffer Tube Number	Buffer Tube Color
1	Blue
2	Orange
3	Green

   d. Each buffer tube shall contain 12 single mode fibers. Each fiber shall be numbered and distinguishable by means of the color coding established in the main body of the specification.

e. The colors of the individual fibers shall be stable across the specified storage and operating temperature range and not subject to fading or smearing onto each other or into the gel filling material. Colors shall not cause fibers to stick together.
f. The fibers shall not adhere to the inside walls of the loose buffer tube. Buffer tubes shall be kink resistant within the specified minimum bend radius.
g. Filler may be included in the cable core composition to lend symmetry to the cable cross-section where needed.
h. A central anti-buckling member shall be included into the cable to prevent buckling of the cable. The anti-buckling member shall be composed of a glass reinforced plastic rod.
i. Each buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional nontoxic solvents.
j. Buffer tubes shall be stranded around a central member using the reverse oscillation, or "S-Z", stranding process.
k. The cable core shall contain a water-blocking material. The water blocking material shall be non-nutritive to fungus, electrically non-conductive and homogenous. It shall also be free from dirt arid foreign matter and shall be readily removable with conventional nontoxic solvents.
l. Binders shall be applied with sufficient tension to secure the buffer tubes to the member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking and dialectic with low shrinkage.
m. Tensile strength shall be provided by a combination of high tensile strength dielectric yarns. The high tensile strength dielectric yarns shall be helically stranded evenly around the cable core.
n. The all-dielectric cable shall be sheathed with medium density polyethylene (MDPE). The minimum nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and water blocking material. The jacket or sheath shall be free of holes, splits, and blisters. The cable jacket shall contain no metallic elements and shall be of a consistent thickness.
o. The cable shall contain at least one ripcord under the sheath for easy sheath removal.

7. Fan-Out Termination for Loose Tube Cables
   a. Individual fibers within the loose tube cable require handling protection inside the termination cabinets. Fan-out kits shall be installed in the patch panel enclosures to transition the loose tube fibers to ruggedized tight-buffered fiber pigtail cables. Fan-out tubes or furcation kits shall not be used. Optical fusion splices shall connect the loose tube fibers to the tight-buffered pigtail cables. The optical splice loss shall comply with the specifications for optical splices. Splice protection sleeves shall be employed on all splices to protect the splices. A wall-mountable splice center shall house the splices and serve to fully protect excess lengths of loose tube fibers from exposure.
   b. The tight-buffered pigtails shall be terminated with ST connectors as specified.
8. Fan-out Pigtail Cable Specifications
   a. Singlemode fiber (Corning SMF-28) shall be used in the pigtails. Optical characteristics shall comply with the optical fiber performance specifications.

Buffer material	Thermoplastic
Buffer O.D.	900 um
Strength Member	Kevlar
Jacket Material	PVC
Jacket O.D.	3.0 mm
Temperature Range	-20 to +70 C

9. Fiber Optic Termination Patch Panels:
   a. Where shown on the plans or in the Appendix, the fiber optic cable shall terminate inside a communications cabinet on a termination patch panel. All fiber sub-cables within the cable shall be terminated with "ST™ compatible" connectors. The patch panel shall have a 24-fiber capacity, and shall facilitate fiber-optic cable cross-connection between outside plant

cables and opto-electronic interface equipment cabling. The patch panel shall contain "ST™" type bayonet couplings. All unused couplings shall have protective dust covers. Factory-terminated, tight-buffered, aramid-reinforced fiber optic jumper assemblies or interconnect cables, standard 3.0-mm O.D., shall connect the optical cable terminations to the patch panel couplings.

b. The termination panel shall be equipped with a suitable means for routing and securing of cables and shall provide a suitable means of protection for the mounted fiber connectors, to prevent damage to fibers arid connectors during all regular operation and maintenance functions. Bend diameters on cable fibers and jumpers must be greater than four (4) inches at all times to ensure optical and mechanical integrity of the optical fibers.

10. Optical Connectors
    a. All connectors shall be field-installable and perfectly matched to the cable used. The connectors shall provide tight fitting termination, to the cladding and buffer coating. Epoxy-based or "hot melt " adhesives shall be used to bond the fiber and buffer to the connector ferrule and body prior to polishing the end face. No dry-termination or "quick crimp" connectors are allowed.
    b. After termination with connectors, the fiber ends must be visually inspected at a magnification of not less than 100 power to check for cracks or pits in the end face of the fiber. If any irregularities found cannot be removed by further polishing, the entire process must be redone by cutting off and disposing the connector body.
    c. Connectors shall have a maximum allowable connection loss of 0.3 dB per mated pair, as measured per EIA-455-34. No index-matching gel is to be used, dry interfaces only. Singlemode connectors shall be capable of field installation on 9/125 micron fibers with 900 micron buffers (OD).
    d. Each connector shall be of the industry standard ST type compatible, designed for singlemode tolerances, and shall meet or exceed the applicable provisions of EIA-455-5, 455-2A, and 455-34, and shall be capable of 100 repeated matings with a maximum loss increase of 0.1 dB. Connectors shall incorporate a key-way design and shall have a zirconia ceramic ferrule. Connector bodies and couplings shall be made of corrosion-resistant and oxidation-resistant materials, such as nickel plated zinc, designed to operate in humid environments without degradation of surface finishes.
11. Splice Closures:
    a. Splice closures shall be of the re-enterable type, with an external moisture-proof shell, inner closure and encapsulant.
    b. Closure shall have removable interior splice trays.
    c. Closures shall be Corning Cable Systems (Siecor) type SCN or equal.

EXECUTION

Fiber Optic Cable Installation

12. General:
    a. The Contractor shall determine a suitable cable installation method to ensure that all cable installation requirements shall be met in all conduit sections. All work shall be carried out in accordance and consistent with the highest standards of quality and craftsmanship in the communication industry with regard to the electrical and mechanical integrity of the connections; the finished appearance of the installation; as well as the accuracy and completeness of the documentation.
    b. The Contractor shall make a physical survey of the project site for the purpose of establishing the exact cable routing and cutting lengths prior to the commencement of any work or committing any materials.
    c. The cable shall be carefully inspected for jacket defects as it is removed from the reel. If defects are noticed, the pulling operation shall be terminated immediately and the the Owner notified.

d. Precautions shall be taken during installation to prevent the cable from being kinked or crushed. Crushed or kinked cable shall be replaced with new cable. As the cable is pulled into the conduit system, it shall be sufficiently lubricated with a lubricant that shall be the water-based type and approved by the cable manufacturer. Lubricant shall be applied at a rate to provide a continuous 10-mil coating, as recommended by the manufacturer. Lubricant shall be Polywater F® manufactured by American Polywater, or approved equivalent.
e. The mechanical stress placed upon the cable during installation shall not be such that the cable is twisted and stretched or exceeds manufacturer's specifications.
f. The pulling of the cable shall be hand assisted at each handhole or pullbox. When pulling through intermediate pullboxes, the cable shall be placed on the ground near the pullbox and care taken to prevent damage by vehicles or other objects. The cable shall not be crushed, kinked or forced around a sharp corner. A minimum of 3 foot slack shall be left in each pullbox and enough left at each end of the cable to allow proper cable termination.

13. Fiber optic cables shall be installed in continuous lengths without intermediate splices throughout the project. Cable installation personnel shall be familiar with the manufacturer's recommended procedures including, but not limited to the following:
    a. Proper attachment to the cable strength elements for pulling during installation. Depending on cable design, this will involve direct attachment to internal strength members or attaching an external "Kellums" or split mesh grip using a 600 lb breakaway swivel.
    b. Cable tensile limitations and tension monitoring procedures.
    c. Cable bending radius limitations.
    d. Cable twisting limitations.
14. The Contractor shall comply with the cable manufacturer's recommended installation procedures at all times. Cable installation procedures shall conform to Belcore guidelines.
15. To accommodate long continuous installation lengths, bi-directional "center pull" techniques for pulling of the fiber optic cable is acceptable and shall be implemented as follows:
    a. From the midpoint, pull the fiber optic cable into the conduit from the shipping reel in accordance with the manufacturer's specifications.
    b. When this portion of the pull is complete, the remainder of the cable must be removed from the reel to make the inside end available for pulling in the opposite direction.
    c. This is accomplished by hand pulling the cable from the reel and laying into large "figure eight" loops on the ground.
    d. The purpose of the figure eight pattern is to avoid cable tangling and kinking.
    e. The loops shall be laid carefully one upon the other (to prevent subsequent tangling) and shall be in a protected area.
    f. The inside reel end of the cable is then available for installation.
    g. In some cases, it may be necessary to set up a winch at an intermediate cable vault.
    h. The required length of cable shall be pulled to that point, and brought out of the cable vault and coiled into a figure eight.
    i. The figure eight is then turned over to gain access to the free cable end. This can then be reinserted into the duct system for installation into the next section.
16. At pullboxes, the Contractor shall provide 30 feet of cable slack. The fiber optic cable shall be coiled and secured with cable ties in the pullbox. The Contractor shall ensure that the minimum bending radius of the fiber optic cable is not compromised when preparing this stored cable slack.
17. The pulling eye/sheath termination hardware on the fiber optic cables shall not be pulled over any sheave blocks.
18. When power equipment is used to install fiber optic cabling, the pulling speed shall not exceed 30 meters per minute. The pulling tension, bending radius and twist limitation for fiber optic cable shall not be exceeded under any circumstances.
19. Large diameter wheels, pulling sheaves, and cable guides shall be used to maintain the appropriate bending radius. Tension monitoring shall be accomplished using commercial dynamometers or loadcell instruments.
    a. All pulls shall be documented by a graph which is annotated with the following information:
        1) Reel number
        2) Station from and station to

3) Date and tune
4) Explanations of abnormalities in readings or interruptions
5) Sign-off by Contractor and the Owner

b. Under no conditions shall the FOC be left exposed or unattended.

20. Repairs: Repair of cable jacket will not be permitted. Jacket damage will require removal and re-installation of a new cable run at the Contractor's expense.
21. Splicing:
    a. Splicing of fiber optic cable shall not be permitted except in emergency conditions or as specified on the plans or in the special conditions for a specified project. Fiber optic cable runs and required looping of the cable shall be provided in one continuous length. When splicing is authorized by the the Owner, splicing shall be by trained, authorized persons only. Any allowed splicing of fiber optic cable shall be by fusion splice only, no mechanical splices are permitted.
    b. All fusion splicing equipment shall be in good working order, properly calibrated, and meeting all industry standards and safety regulations. Cable preparation, closure installation and splicing shall be accomplished in accordance with accepted and approved industry standards.
    c. Spices shall be made in pullboxes and shall use re-enterable splice closures.
    d. The average splice loss shall be 0.1 dB or less per splice. The average splice loss is defined as the summation of the loss as measured in both directions using an optical time domain reflectometer (OTDR) through the fusion splice, divided by two. No individual splice loss measured in a single direction shall exceed 0.15 dB.
    e. Upon completion of the splicing operation, all waste material shall be deposited in suitable containers, removed from the job site, arid disposed of in an environmentally acceptable manner.
22. After the cables are installed and spliced, they shall be racked and all conduits sealed. A minimum of 30 feet of FOC shall be stored at each end of one splice. Racking shall conform to the following:
    a. Cables shall be loosely secured in racked position with Ty-Raps or equal.
    b. Imprinted plastic coated cloth identification/warning tags shall be securely attached to the cables in at least two locations in each handhole. Tags shall be by Brady or Thomas & Betts.
    c. All coiled cable shall be suitably protected to prevent damage to the cable and fibers. Racking shall include securing cables to brackets and racking hardware that extend from the sidewalls of the handhole.
    d. When all cables at each handhole are securely racked, unused conduits and void areas around conduit containing cables shall be sealed.

Cable Protection During Installation

23. All fiber optic cable shall be pulled in conduit except as specified on the plans. Care shall be exercised during cable pulls through conduit bends and looping in pull boxes.
24. To reduce the possibility of damage to the outer jacket of the fiber optic cable, protective measures shall be used when the cable is installed. The requirements herein shall be followed, but does not limit the installation to only those identified. The purpose of the installation specifications is to ensure protection, of the fiber optic cable when it is installed. Other protective measures not specified herein may be taken during installation if it will ensure protection of the cable.
25. A cable feeder guide shall be used between the cable reel and the face of the duct and conduit to protect the cable and guide it off the reel and into the duct. The cable shall be carefully inspected for jacket defects as it is removed from the reel. If defects are noticed, the pulling operation shall be terminated immediately and the the Owner notified.
26. Precautions shall be taken during installation to prevent the cable from being kinked, crushed or twisted. A pulling eye shall be attached to the cable end and be used to pull the cable through the duct and conduit system. As the cable is pulled off the reel and into the cable feeder guide, it shall

be sufficiently lubricated with a lubricant that shall be of the water based type and approved by the cable manufacturer.

27. Dynamometers or break away pulling swings shall be used to ensure the pulling line tension does not exceed the installation tension values specified by the cable manufacturer. The mechanical stress placed upon the cable during installation shall not be such that the cable is twisted and stretched. Maximum allowable cable strain during installation shall be less than 0.75%.
28. The pulling of the cable shall be hand assisted at each handhole or pullbox. The cable shall not be crushed, kinked or forced around a sharp corner. Sufficient slack shall be left at each end of the cable to allow proper cable termination.
29. The cable shall be looped in all pull boxes as noted on the plans to provide approximately thirty (30) feet of extra cable in the pull box. At termination points, such as at cabinets or computers, a thirty (30) foot loop shall also be provided wherever space permits.
30. Cable Marking: At each pullbox and at each cabinet, the cable shall be visibly marked with yellow warning tape as follows:

"CAUTION - FIBER OPTIC CABLE"

Fiber Optic Cable Testing

31. General: The Contractor shall perform pre-installation and post-installation FOC tests. The the Owner shall be notified a minimum of 10 days in advance so that these tests are witnessed. All test equipment shall be traceable to NIST standards.
32. Test equipment: The Contractor, shall use the following to perform pre-installation and post-installation FOC tests:
    a. Optical time domain reflectometer (OTDR). The OTDR shall be laser precision, ALT Inc. MODEL 5200 LRFL, or equal.
33. Pre-installation tests
    a. The purpose of these tests is to perform acceptance tests on the cable prior to installation to verify that the cable conforms to the manufacturer's specifications, and is free of defects, breaks and damages by transportation and manufacturing processes.
    b. Prior to removal of each cable from the delivery reel, all optical fibers within the cables shall be tested by the Contractor using an OTDR. The OTDR tests shall consist of end-to-end length and fiber attenuation (dB/km) measurements to ensure proper performance of the fiber optic cable. The tests shall be performed from both ends of each fiber to ensure complete fiber continuity within the cable structure.
    c. Pre-installation, "on-reel" test results shall be compared with the manufacturer's test report delivered with the cable. Gross dissimilarities shall be noted and remedied between the Contractor and manufacturer. In all cases, all fibers must meet the optical attenuation specifications prior to cable installation.
    d. The Contractor shall perform tests on all reels of cable. The the Owner shall be notified a minimum of 15 days prior to any test.
    e. The Contractor shall document each test and submit the report to the the Owner for review. Documentation shall consist of both hard copy and 3-1/2 inch electronic disk complete with all application software.
    f. Cable shall not be installed until the the Owner has reviewed the test report.
    g. Maximum allowable attenuation is 0.5 dB/km at 1310 and 1550 nm.
34. Post-installation tests: After FOC has been installed the following tests shall be performed:
    a. A recording OTDR shall be used to test for end-to-end continuity and attenuation of each optical fiber. The OTDR shall be equipped with a 1310 nm and 1550 nm light source for the single mode fiber (SMF). The OTDR shall have an X-Y plotter to provide a hard copy record of each trace of each fiber: The OTDR shall be equipped with sufficient internal masking to allow the entire cable section to be tested. This may be achieved by using an optical fiber pigtail of 30 feet or more to display the required cable section.
    b. The OTDR shall be calibrated for the correct index of refraction to provide proper length measurement for the known length of reference fiber.

c. A transmission test shall be performed with the use of a 1310 and 1550 nm stabilized light sources and 1310 nm/1550 nm power meters for SMF. This test shall be conducted in both directions on each fiber of each cable.
d. Hard and electronic copy of test documentation shall be submitted to the the Owner. The documentation shall include the trace plot, index, dB/km loss, cable length, date and time of test, wavelength, pulse width, the test site, cable ID, fiber number and type, and operator's initials. The Contractor shall compare the pre-installation test results to the post-installation results. If a deviation of greater than one dB occurs, the the Owner shall be notified in writing by the Contractor, and the cable shall be removed and replaced at no additional cost to the Owner.
e. Upon completion of the previous tests all FOC coils shall be secured with ends capped to prevent intrusion of dirt and water.

35. Required OTDR Trace Information:
a. All traces shall display the entire length of cable under test, highlighting any localized loss discontinuities (installation-induced losses and/or connector losses). The trace shall display fiber length (in kilofeet), fiber loss (dB), and average fiber attenuation (in dB/km) as measured between two markers placed as near to the opposite ends of the fiber under test as is possible while still allowing an accurate reading. Care shall be taken to ensure that the markers are placed in the linear region of the trace: away from the front-end response and far-end Fresnel reflection spike. Time averaging shall be used to improve the display signal to noise ratio. The pulse width of the OTDR shall be set to a sufficient width to provide adequate injected power to measure the entire length the fiber under test.
b. If connectors exist in the cable under test, then two traces shall be recorded. One trace shall record the fiber loss (dB) and average attenuation (dB/km) of the entire cable segment under test, including connectors. The second trace shall display a magnified view of the connector regions, revealing the connector losses (dB). All connector losses shall be measured using the 5-point splice loss measurement technique.
c. The OTDR trace shall also include the following information:
    1) The date and time of the test
    2) The cable ID number
    3) The cable segment ID number
    4) The fiber color or sub-cable number
    5) Launch point connector number
    6) The optical wavelength used for the test
    7) The refractive index setting of the OTDR
    8) The pulse width setting of the OTDR
    9) The averaging interval of the test

END OF SECTION 27 11 19 00

Task	Specification	Specification Description
27 11 19 00	26 05 53 00a	Intercommunications and Program Systems
27 11 23 00	26 05 53 00a	Intercommunications and Program Systems
27 13 13 13	26 05 13 16	Conductors And Cables
27 13 13 13	26 05 13 16a	Undercarpet Cables
27 13 13 13	26 05 13 16b	Medium-Voltage Cables
27 13 13 13	26 05 53 00a	Intercommunications and Program Systems
27 13 23 13	27 11 19 00	Loose-Tube Gel-Filled Fiber Optic Cables
27 15 13 00	26 05 13 16	Conductors And Cables
27 15 13 00	26 05 13 16a	Undercarpet Cables
27 15 13 00	26 05 19 16c	Control-Voltage Electrical Power Cables
27 15 13 00	26 05 13 16b	Medium-Voltage Cables
27 15 33 00	26 05 13 16	Conductors And Cables
27 15 33 00	26 05 13 16a	Undercarpet Cables
27 15 33 00	26 05 19 16c	Control-Voltage Electrical Power Cables
27 15 33 00	26 05 13 16b	Medium-Voltage Cables
27 15 43 00	26 05 53 00a	Intercommunications and Program Systems
27 15 53 00	27 11 19 00	Loose-Tube Gel-Filled Fiber Optic Cables
27 16 16 00	27 11 19 00	Loose-Tube Gel-Filled Fiber Optic Cables
27 16 19 00	26 05 13 16	Conductors And Cables
27 16 19 00	27 11 19 00	Loose-Tube Gel-Filled Fiber Optic Cables
27 21 16 00	27 11 19 00	Loose-Tube Gel-Filled Fiber Optic Cables
27 21 16 00	26 05 53 00a	Intercommunications and Program Systems
27 31 13 00	26 05 53 00a	Intercommunications and Program Systems
27 32 13 00	26 05 33 16a	Wiring Devices
27 32 13 00	26 05 53 00a	Intercommunications and Program Systems
27 32 26 00	26 05 53 00a	Intercommunications and Program Systems

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SECTION 27 51 43 00 - EDUCATIONAL INTERCOMMUNICATIONS AND PROGRAM SYSTEMS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for educational intercommunications and program systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes: Manually switched intercommunications, Microprocessor-switched intercommunications, Microprocessor-switched telephone/intercommunications and program systems with the following components:
a. Master stations.
b. Call control console.
c. Speaker-microphone stations.
d. Call-switch unit.
e. All-call amplifier.
f. Intercommunication amplifier.
g. Paging amplifier.
h. Loudspeakers/speaker microphones.
i. Conductors and cables.
j. Raceways.

C. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For educational intercommunications and program systems. Include plans, elevations, sections, details, and attachments to other work.
a. Wiring Diagrams: For power, signal, and control wiring.
1) Identify terminals to facilitate installation, operation, and maintenance.
2) Single-line diagram showing interconnection of components.
3) Cabling diagram showing cable routing.
3. Field quality-control reports.
4. Operation and maintenance data.

D. Quality Assurance
1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for location and application.
3. Comply with NFPA 70.

1.2 PRODUCTS

A. Functional Description Of Manually Switched Systems
1. Master Station:
a. Communicating selectively with other master and speaker-microphone stations by actuating selector switches.
b. Communicating simultaneously with all other stations by actuating a single all-call switch.
c. Communicating with individual stations in privacy.
d. Including other master-station connections in a multiple-station conference call.

e. Accessing separate paging speakers or groups of paging speakers by actuating selector switches.
f. Overriding any conversation by a designated master station.

2. Speaker-Microphone Station:
   a. Having privacy from remote monitoring without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
   b. Communicating hands free.
   c. Calling master station by actuating call switch.
   d. Returning a busy signal to indicate that station is already in use.
   e. Being free of noise and distortion during operation and when in standby mode.
3. Speakers: Free of noise and distortion during operation and when in standby mode.

B. Functional Description Of Microprocessor-Switched Systems
1. Master Station:
   a. Communicating selectively with other master and speaker-microphone stations by dialing station's number on a 12-digit keypad.
   b. Communicating with individual stations in privacy.
   c. Communicating on a minimum of three voice channels with up to two simultaneous conversations between master stations and one conversation between a master station and a speaker-microphone station.
   d. Increasing the number of conversation channels by adding a module in central-control cabinet.
   e. Including up to three other station connections in a conference call.
   f. Accessing separate paging speakers or groups of paging speakers by dialing designated numbers on a 12-digit keypad.
   g. Overriding any conversation by a designated master station.
   h. Displaying selected station.
   i. Communicating simultaneously with all other stations by dialing a designated number on a 12-digit keypad.
   j. Automatically controlling gain to ensure constant intercom speech level.
   k. Controlling the simultaneous distribution of program material to various combinations of speaker-microphone stations or groups over two program channels by using keypad to control sources and distribute programs.
   l. Operating and correcting secondary clocks and controlling class-change signals to speakers and bells by using keypad.
   m. User-programmable features include the following:
      1) Station calling by room number.
      2) Room station call-in priority levels.
      3) Clock signal schedule functions.
      4) Schedule characteristics of audible signals.
      5) Call-in tone characteristic.
      6) Precedence among master stations as destinations for incoming calls from room stations.
      7) Grouping of rooms and speakers into zones for paging and program distribution purposes.
2. Speaker-Microphone Station:
   a. Having privacy from remote monitoring without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
   b. Communicating hands free.
   c. Calling master station by actuating call switch.
   d. Returning a busy signal to indicate that station is already in use.
3. Speakers: Free of noise and distortion during operation and when in standby mode.

C. Functional Description Of Telephone/Intercommunication Systems
1. Integrated central system with the following:
a. Direct-dial, full duplex private telephone communications between all locations equipped with telephones. Call initiation among master stations and between master and remote stations by dialing station's number on a 12-digit keypad.
b. 16 channels for unrestricted simultaneous communications.
c. Initial system operation with <**Insert number**> master and remote stations, expandable to 360 stations.
d. Direct-dial, two-way amplified voice intercommunication between master telephones and remote stations without use of press-to-talk or talk-listen switches.
e. Automatic queuing for intercommunication channels, with automatic call waiting.
f. Call transfer among master stations.
g. Display of selected station and answering calling station by pressing a single "response button."
h. Simultaneous communication with other stations on system by dialing a designated number on a 12-digit keypad.
i. Automatic gain control to ensure constant intercom speech level.
j. Simultaneous distribution of emergency announcements to all locations equipped with speakers by dialing a predetermined code number.
k. User-selectable facility for providing selected telephones with dial tone.
l. User-selectable facility for permitting linkage of selected stations to media retrieval center and for permitting on- and off-premise computer linkage.
m. Assignment of speaker locations within any one or more of eight zones for zone paging or time signal reception.
n. Digital readout displays on which up to three incoming calls are displayed with additional calls stored for subsequent display.
o. Off-site diagnostics through a serial data port on central-control station.
p. Control of simultaneous distribution of program material to various combinations of remote stations or groups by using keypad to control sources and distribute programs.
q. Operation and correction of secondary clocks and control of class-change signals to speakers and bells by using keypad.
r. User-programmable features include the following:
1) Station calling by room number.
2) Room station call-in priority levels.
3) Clock signal schedule functions.
4) Schedule characteristics of audible signals.
5) Call-in tone characteristic.
6) Precedence among master stations as destinations for incoming calls from room stations.
7) Grouping rooms and speakers into zones for paging and program distribution purposes.
s. Telephone interconnect features include the following:
1) Direct connection to central office trunk lines with initial system wiring for <**Insert number**> trunk lines.
2) Routing of outside trunk lines for "attendant answer incoming" and "direct inward line" functions.
3) Station programming for access to outside trunk lines to be any of the following:
a) Totally unrestricted access.
b) Restricted access.
c) No access.
4) System programming to allow or disallow local prefixes, and to authorize access for as many as three area codes.
5) Discriminating ringing for identifying internal and outside calls.
6) Circular hunting for outside trunks to prevent excess usage of any one trunk.
7) Direct connection of a single trunk to designated telephone with transfer to attendant if unanswered.

8) Call parking allowing paged party to remotely pick up outside call from any master station.
9) Night-answer mode to allow one or all of the following:
   a) Incoming call transferred to predetermined extension.
   b) Tone transmitted to speakers to notify key personnel to answer telephone.
   c) Dial tone to remote stations to allow answering call from all locations.
10) Call control console to do as follows:
   a) Identify, answer, and route incoming outside calls, with reminder and recall features.
   b) Directly access outside trunk lines.
   c) Hold, park, and transfer calls.
   d) Screen outside calls.

2. Remote Stations:
   a. Speaker-Microphone Station:
      1) Having privacy from remote monitoring without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
      2) Communicating hands free.
      3) Calling master station by actuating call switch.
      4) Returning a busy signal to indicate that station is already in use.
3. Speakers: Free of noise and distortion during operation and when in standby mode.

D. General Requirements For Equipment And Materials
1. Coordinate features and select components to form an integrated system. Match components and interconnections for optimum performance of specified functions.
2. Expansion Capability: Increase number of stations in the future by 25 percent above those indicated without adding any internal or external components or main trunk cable conductors.
3. Equipment: Modular type using solid-state components, fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz. Comply with UL 813.
4. Weather-Resistant Equipment: Listed and labeled by an NRTL for duty outdoors or in damp locations.

E. Master Station For Manually Switched Systems
1. Station-Selector and Talk-Listen Switches: Heavy-duty type with gold-plated contacts rated for five million operations.
2. Volume Control: Regulates incoming-call volume.
3. LED Annunciation: Identifies calling stations and stations in use. LED remains on until call is answered.
4. Tone Annunciation: Momentary audible tone signal announces incoming calls.
5. Speaker Microphone: Transmits and receives calls.
   a. Minimum Speaker Sensitivity: 91 dB at one meter, with 1-W input.
6. Handset with Hook Switch: Telephone type with 18-inch- (450-mm-) long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.
7. Central-Equipment Cabinet: Comply with TIA/EIA-310-D. Lockable, ventilated metal cabinet houses terminal strips, power supplies, amplifiers, system volume control, and auxiliary equipment.

F. Master Station For Microprocessor-Switched Systems
1. 12-Digit Keypad Selector: Transmits calls to other stations and initiates commands for programming and operation.
2. Volume Control: Regulates incoming-call volume.
3. Tone Annunciation: Momentary audible tone signal announces incoming calls.
4. Lamp Annunciation: Identifies calling stations and stations in use. Lamp remains on until call is answered.

5. Speaker Microphone: Transmits intercom voice signals when used via a voice-operated switch.
   a. Minimum Speaker Sensitivity: 91 dB at one meter, with 1-W input.
6. Link Button: To transfer calls.
7. Reset Control: Cancels call and resets system for next call.
8. Digital Display: 16-digit alphanumeric LCD readout to register up to four three-digit station numbers.
9. Central-Equipment Cabinet: Comply with TIA/EIA-310-D. Lockable, ventilated metal cabinet houses terminal strips, power supplies, amplifiers, system volume control, and other switching and control devices required for conversation channels and control functions.

G. Call Control Console
1. Microprocessor-based instrument to process outside and internal calls with a 12-digit keypad selector.
2. 20-character alphanumeric display for the following:
   a. Simultaneous display of up to three calling stations plus last station dialed.
   b. Display of calls in order received with emergency calls taking precedence on the display.
   c. Review of calls stored in groups of four.
   d. Display of prompt messages to assist in system operation.
3. Programmable Keys: Minimum of 20 with LED indicators for ringing/busy status; programmable for trunk and operator functions.
4. Transfer Button: Calls to busy extensions and unanswered calls automatically returned to call control console.
5. Hold Button: With reminder feature every 30 seconds for parked calls or calls placed on hold.
6. Release Button: For use with parked calls or calls placed on hold.
7. Page Button: For engaging system paging functions.
8. Programmable for night answer, remote answer, and remote pickup features.
9. Programmable for distribution of emergency announcements, all-page announcements, zone-page announcements, and emergency/evacuation alert.
10. Central-Control Cabinet Equipment: Central switching equipment, central office adapter module, line link modules, power supplies, chassis adapters, and other switching and control devices required for trunk and internal conversation channels and control functions.

H. Speaker-Microphone Stations
1. Mounting: Flush unless otherwise indicated, and suitable for mounting conditions indicated.
2. Faceplate: Stainless steel or anodized aluminum with tamperproof mounting screws.
3. Back Box: Two-gang galvanized steel with 2-1/2-inch (64-mm) minimum depth.
4. Speaker: Minimum axial sensitivity shall be 91 dB at one meter, with 1-W input. Voice coil shall be not less than 3 inches (76 mm), 2.3 oz. (65 g) minimum; permanent magnet.
5. Tone Annunciation: Recurring momentary tone indicates incoming calls.
6. Call Switch: Mount on faceplate. Permits calls to master station.
7. Privacy Switch: Mount on faceplate. When in on position, switch prevents transmission of sound from remote station to system; when in off position, without further switch manipulation, response can be made to incoming calls.

I. Call-Switch Unit
1. Enclosure: Single-gang box with stainless-steel faceplate.
2. Call Switch: Momentary contact signals system that a call has been placed.
3. Privacy Switch: Prevents transmission of sound signals from station to system.
4. Volume Control: Operated by screwdriver blade through a hole in faceplate to adjust output level of associated speaker.

J. All-Call Amplifier
1. Output Power: 70-V balanced line. 80 percent of the sum of wattage settings of connected for each station and speaker connected in all-call mode of operation, plus an allowance for future stations.

2. Total Harmonic Distortion: Less than 5 percent at rated output power with load equivalent to quantity of stations connected in all-call mode of operation.
3. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.
4. Frequency Response: Within plus or minus 2 dB from 50 to 12,000 Hz.
5. Output Regulation: Maintains output level within 2 dB from full to no load.
6. Input Sensitivity: Compatible with master stations and central equipment so amplifier delivers full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on master stations, speaker microphones, or handset transmitters.
7. Amplifier Protection: Prevents damage from shorted or open output.

K. Intercommunication Amplifier
1. Minimum Output Power: 15 W; adequate for all functions.
2. Total Harmonic Distortion: Less than 5 percent at rated output power with load equivalent to one station connected to output terminals.
3. Minimum Signal-to-Noise Ratio: 50 dB, at rated output.
4. Frequency Response: Within plus or minus 3 dB from 70 to 10,000 Hz.
5. Output Regulation: Maintains output level within 2 dB from full to no load.
6. Input Sensitivity: Matched to input circuit and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on microphones in master stations, speaker microphones, or handset transmitters.
7. Amplifier Protection: Prevents damage from shorted or open output.

L. Paging Amplifier
1. Input Voltage: 120-V ac, 60 Hz.
2. Frequency Response: Within plus or minus 3 dB from 60 to 10,000 Hz.
3. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.
4. Total Harmonic Distortion: Less than 3 percent at rated output power from 70 to 12,000 Hz.
5. Output Regulation: Less than 2 dB from full to no load.
6. Controls: On-off, input levels, and low-cut filter.
7. Input Sensitivity: Matched to input circuit and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on speaker microphones or handset transmitters.
8. Amplifier Protection: Prevents damage from shorted or open output.

M. Cone-Type Loudspeakers/Speaker Microphones
1. Minimum Axial Sensitivity: 91 dB at one meter, with 1-W input.
2. Frequency Response: Within plus or minus 3 dB from 70 to 15,000 Hz.
3. Minimum Dispersion Angle: 100 degrees.
4. Line Transformer: Maximum insertion loss of 0.5 dB, power rating equal to speaker's, and at least four level taps.
5. Enclosures: Steel housings or back boxes, acoustically dampened, with front face of at least 0.0478-inch (1.2-mm) steel and whole assembly rust proofed and factory primed; complete with mounting assembly and suitable for surface ceiling, flush ceiling, pendant or wall mounting; with relief of back pressure.
6. Baffle: For flush speakers, minimum thickness of 0.032-inch (0.8-mm) aluminum brushed to a satin sheen and lacquered **OR** with textured white finish, **as directed**.
7. Vandal-Proof, High-Strength Baffle: For flush **OR** surface, **as directed**,-mounted speakers, self-aging cast aluminum with tensile strength of 44,000 psi (303 MN/sq. m), 0.025-inch (0.65-mm) minimum thickness; countersunk heat-treated alloy mounting screws; and textured white epoxy finish.
8. Size: 8 inches (200 mm) with 1-inch (25-mm) voice coil and minimum 5-oz. (140-g) ceramic magnet.

N. Horn-Type Loudspeakers/Speaker Microphones
1. Speakers shall be all-metal, weatherproof construction; complete with universal mounting brackets.

2. Frequency Response: Within plus or minus 3 dB from 275 to 14,000 Hz.
3. Minimum Power Rating of Driver: 15 W, continuous.
4. Minimum Dispersion Angle: 110 degrees.
5. Line Transformer: Maximum insertion loss of 0.5 dB, power rating equal to speaker's, and at least four level taps.

O. Conductors And Cables
1. Conductors: Jacketed, twisted pair and twisted multipair, untinned solid copper. Sizes as recommended by system manufacturer, but no smaller than No. 22 AWG.
2. Insulation: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.
3. Shielding: For speaker-microphone leads and elsewhere where recommended by manufacturer; No. 34 AWG, tinned, soft-copper strands formed into a braid or equivalent foil.
   a. Minimum Shielding Coverage on Conductors: 60 percent.
4. Plenum Cable: Listed and labeled for plenum installation.

P. Raceways
1. Educational Intercommunication and Program System Raceways and Boxes: Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems".
2. Educational Intercommunication and Program System Raceways and Boxes: Same as required for electrical branch circuits specified in Division 26 Section "Raceway And Boxes For Electrical Systems".
3. Educational Intercommunication and Program System Raceways and Boxes: EMT **OR** ENT **OR** RNC **OR** Optical-fiber/communication raceways and fittings **OR** Metal wireways **OR** Nonmetal wireways **OR** Surface metal raceways **OR** Surface nonmetal raceways, **as directed**.
4. Outlet boxes shall be not less than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.
5. Flexible metal conduit is prohibited.

1.3 EXECUTION

A. Wiring Methods
1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters, and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used, **as directed**. Conceal raceway and cables except in unfinished spaces.
   a. Install plenum cable in environmental air spaces, including plenum ceilings.
   b. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway And Boxes For Electrical Systems".
2. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
3. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

B. Installation Of Raceways
1. Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems" for installation of conduits and wireways.
2. Install manufactured conduit sweeps and long-radius elbows whenever possible.

C. Installation Of Cables
1. Comply with NECA 1.
2. General Requirements:
   a. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.

b. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
c. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
d. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
e. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
f. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used.

3. Open-Cable Installation:
a. Install cabling with horizontal and vertical cable guides in telecommunication spaces with terminating hardware and interconnection equipment.
b. Suspend speaker cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceiling by cable supports not more than 60 inches (1524 mm) apart.
c. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.

4. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches (300 mm) apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.

D. Installation
1. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
2. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.
3. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.
4. Connect wiring according to Division 26 Section "Grounding And Bonding For Electrical Systems".

E. Grounding
1. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
2. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.
3. Install grounding electrodes as specified in Division 26 Section "Grounding And Bonding For Electrical Systems".

F. System Programming
1. Programming: Fully brief the Owner on available programming options. Record the Owner's decisions and set up initial system program. Prepare a written record of decisions, implementation methodology, and final results.

G. Field Quality Control
1. Perform tests and inspections.
a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

2. Tests and Inspections:
   a. Schedule tests with at least seven days' advance notice of test performance.
   b. After installing educational intercommunications and program systems and after electrical circuitry has been energized, test for compliance with requirements.
   c. Operational Test: Test originating station-to-station **OR** originating station-to-station, all-call, and page, **as directed**, messages at each intercommunication station. Verify proper routing and volume levels and that system is free of noise and distortion. Test each available message path from each station on system.
   d. Frequency Response Test: Determine frequency response of two transmission paths, including all-call and paging, **as directed**, by transmitting and recording audio tones. Minimum acceptable performance is within 3 dB from 150 to 2500 Hz.
   e. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:
      1) Disconnect speaker microphone and replace it in the circuit with a signal generator using a 1000-Hz signal. Measure signal-to-noise ratio at paging, **as directed**, speakers.
      2) Repeat test for three speaker microphones, one master station microphone, and for each separately controlled zone of paging loudspeakers.
      3) Minimum acceptable ratio is 45 dB.
   f. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 150, 200, 400, 1000, and 2500 Hz into each intercom **OR** intercom, paging, and all-call amplifier, **as directed**. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 5 percent total harmonics.
   g. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each paging zone. Maximum permissible variation in level is plus or minus 3 dB; in levels between adjacent zones, plus or minus 5 dB.
   h. Power Output Test: Measure electrical power output of each paging amplifier at normal gain settings of 150, 1000, and 2500 Hz. Maximum variation in power output at these frequencies is plus or minus 3 dB.
   i. Signal Ground Test: Measure and report ground resistance at system signal ground. Comply with testing requirements in Division 26 Section "Grounding And Bonding For Electrical Systems".
3. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging and independent room speaker-line matching transformers.
4. Educational intercommunications and program systems will be considered defective if they do not pass tests and inspections.
5. Prepare test and inspection reports.

END OF SECTION 27 51 43 00

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Task	Specification	Specification Description
27 51 43 00	26 33 43 00b	Public Address and Mass Notification Systems

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SECTION 27 53 13 13 - CLOCK AND PROGRAM CONTROL

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for clock and program control. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
2. Master clock and program control unit.
3. Secondary indicating clocks.
4. Program signal devices.
5. Clock circuit power boosters.
6. Interface with intercom and public-address system.
7. System wire and cable.

C. Definitions
1. NIST: The National Institute of Science and Technology.
2. PC: Personal computer.
3. UTC: Universal time coordinated. The precisely measured time at zero degrees longitude; a worldwide standard for time synchronization.

D. Performance Requirements
1. Seismic Performance: Master clock and housing shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals
1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes (including available colors) for each product indicated and describe features and operating sequences, both automatic and manual.
2. Shop Drawings: For clock systems. Include plans, elevations, sections, details, and attachments to other work.
   a. Wiring Diagrams: For power, signal, and control wiring and correction circuits.
      1) Identify terminals and wiring color codes to facilitate installation, operation, and maintenance.
      2) Indicate recommended wire types and sizes, and circuiting arrangements for field-installed system wiring. Show protection from overcurrent, static discharge, and voltage surge.
   b. Details of seismic restraints including mounting, anchoring, and fastening devices for the following system components:
      1) Surface-mounted and semirecessed secondary indicating clocks.
      2) Master clock enclosures **OR** mounting racks, **as directed**.
      3) Clock circuit power boosters.
   c. Details of seismic strengthening of master clock enclosures **OR** mounting racks, **as directed**.

d. Dimensioned Outline Drawings of the Mounting Rack for the Master Clock: Show internal seismic bracing, and locate center of gravity of fully equipped and assembled unit. Locate and describe mounting and anchorage provisions.

3. Delegated-Design Submittal: For the master clock and housing indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   a. Detail fabrication and assembly of the master clock and housing.
   b. Design Calculations: Calculate requirements for selecting seismic restraints.
4. Seismic Qualification Certificates: For the master clock, accessories, and components, from manufacturer.
5. Field quality-control reports.
6. Operation and maintenance data.

F. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NFPA 70.

1.2 PRODUCTS

A. Master And Secondary Clock System
1. System Functions and Features:
   a. Supply power to remote indicating clocks except those indicated to have correction signals applied through a data circuit.
   b. Maintain correct synchronized time and transmit time-correction signals over dedicated system wiring from a master clock to any one **OR** two, **as directed**, type(s) of secondary indicating clocks, including the following:
      1) Analog Synchronous Clocks: Correct for minute- and second-hand synchronization at least once each hour and for hour-hand synchronization at least once each day.
      2) Digital Clocks: Test clocks automatically for synchronization with master time control at least once every hour and automatically correct those not synchronized with the time reference unit. Automatically correct clocks immediately when power is restored after an outage of power to the master clock.
   c. Initiate and execute programs for scheduled automatic operation of remote devices. Include audible signal devices and visual signal devices, **as directed**, and on and off switching of equipment and circuits, **as directed**.
   d. Provide for manual control of programmed signal and equipment-switching circuits.
   e. Communicate with remote PC for access to UTC time base and to permit programming from remote location, **as directed**.
   f. Maintain system access security with a minimum of one level **OR** two levels **OR** three levels, **as directed**, of user-access control to restrict use of system controls to authorized personnel. Levels of access apply to both local access and access from a remote computer, **as directed**. Access to user programming and control functions is accomplished by entering a minimum three-digit code. Access levels include the following:
      1) Access to review existing programs only.
      2) Access to normal system operating controls.
      3) Access to all user-programming and control functions.
   g. Regulate system timing functions using power-line frequency, backed up for power outages by an internal battery-powered, crystal-controlled oscillator.
      OR
      Regulate system timing functions using power-line frequency, backed up for power outages by an internal battery-powered, crystal-controlled oscillator, and automated periodic reference to NIST or UTC time signals via internal telephone modem and automatic dialup connection **OR** internal modem and network or microcomputer Internet

access **OR** dedicated internal radio receiver tuned to NIST time signal broadcasts, **as directed**. Reference time signals shall be automatically accessed at programmable intervals.

h. Provide for programming multiple independent event schedules into memory and running them simultaneously for different output circuits.
   1) Quantity of Programmable Schedules: Three **OR** Four **OR** Eight **OR** 18 **OR** 250, **as directed**, minimum.
   2) Number of Weekly Events That Can Be Programmed for Each Schedule: 64 **OR** 128 **OR** 300 **OR** 600 **OR** 2500, **as directed**, minimum.
   3) Simultaneous operation of independent schedules shall be limited only by the number of signal-device and equipment-switching output circuits.
   4) Advance Programming for Automatic Holiday Schedule Changes: Number of schedule changes that can be programmed to suit holidays and vacations shall be 10 **OR** 16 **OR** 50 **OR** 100, **as directed**, and each change may be programmed up to a year in advance to occur on any day of the calendar year.

i. Automatically check functioning of LEDs, switches, input keys, central processor, read-only memory, random access memory, and output circuits. A display on the control panel or a remote computer with the proper access code, **as directed**, shall indicate failure by identifying faulty component or circuit and shall recommend corrective action.

j. Provide manually initiated **OR** programming for automatic, **as directed**, daylight savings time correction.

k. Provide for adjustments to master clock output signals. Duration of momentary signal shall be individually programmable for each signal and equipment-control output circuit from 1 to 99 seconds. Signals shall be programmable for either on or off switching to suit equipment-operation scheduling.

B. Master Clock

1. Description: Microprocessor-based, software-controlled unit complying with Class A device requirements in 47 CFR 15.
   a. Programming and control switches.
   b. Informational Display: LED or backlit LCD type.
      1) Normally shows current time, date, and day of week, **as directed**, display.
      2) Provides programming cues when system is being programmed.
   c. Output Circuits for Power and Correction of Secondary Indicating Clocks:
      1) Wired Synchronous Clock Power-and-Correction Circuits: For analog and digital, **as directed**, clocks; a minimum of one **OR** two, **as directed**, required. Relay controlled.

         OR

         Wired Synchronous Digital Clock Power-and-Correction Circuits: One, **as directed**, required.
      2) Existing Clock Power-and-Correction Circuit: An output circuit suitable for the of existing power-and-correction circuit and number of clocks to be connected.
   d. Data Output Port for Digital, **as directed**, Secondary Clock Correction Circuit: RS485 or similar circuit for scheduled periodic correction signals.
   e. Modem and PC interface software suitable for remote programming and automatic NIST or UTC synchronization, **as directed**.
   f. Circuits for Audible and Visual, **as directed**, Signal Devices: Relay controlled, manually switchable, using controls on the master clock. Rated 120-V ac, five **OR** 10, **as directed,** A minimum. A minimum of two **OR** four **OR** six **OR** eight, **as directed**, circuits.
   g. Circuits for Programmable Switching of Remote Equipment and Circuits: Relay controlled, manually switchable, using controls on the master clock. Rated 120-V ac, 5 **OR** 10, **as directed**, A minimum. A minimum of two **OR** four **OR** six **OR** eight, **as directed**, circuits.
   h. Power Supplies: Capacity for internal loads and power-and correction circuits of connected clocks.

i. Enclosure: Metal cabinet with locking front panel. When cabinet is locked, display indication shall be visible on or through front panel face. Arrange cabinet for surface, semirecessed, or flush mounting as indicated.
OR
Housing: Rack-mounting metal enclosure with display indication visible on front panel face.
1) Reinforce mounting and attachment capable of resisting seismic forces described in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".

j. Battery Backup for Time Base: Lithium battery to maintain the timekeeping function and retain the programs in memory during outage of normal ac power supply for up to 10 years.

k. Electrostatic Discharge Resistance: Master clock and secondary indicating clocks, **as directed**, shall be tested and certified according to IEC 61000-4-2 in both human-discharge and direct-injection modes.

C. Secondary Indicating Clocks

1. Analog Clock: Equipped with a sweep second hand. Movement shall be driven by self-starting, permanently lubricated, sealed synchronous motor equipped with a correcting solenoid actuator, or be a microprocessor-based, second impulse unit, compatible with the master clock.

2. Digital Clock: Microprocessor-controlled unit complying with Class A device requirements in 47 CFR 15, with red LED digital time display of hours and minutes **OR**, minutes, and seconds, **as directed**.
   a. Display Height: 2-1/2-Inch (64-mm) Clock: Hour and minute numerals readable at 50 feet (15 m).
   OR
   Display Height: 4-Inch (102-mm) Clock: Hour and minute numerals readable at 100 feet (30 m).
   b. Display Format: Selectable between 12-hour with "PM" LED display and 24-hour formats.
   c. Connections for Power and Correction:
      1) Wired synchronous connection to the master clock for both operating power and correction.
         a) Time-Base Backup: Internal alkaline battery shall back up internal time base to maintain timekeeping during power outages of up to six days' duration.
         OR
         Time-Base Backup: Internal capacitor shall back up internal time base to maintain timekeeping during power outages of up to 12 hours' duration.
         b) Correction by RS485, Ethernet, or similar data line with operating power supplied over a separate connection.
         c) Power Connection for Secondary Indicating Clocks: Plug connector **OR** Wire pigtail or compression splice, **as directed**.

3. Interval-Timer Clock: Digital microprocessor-controlled, 4-inch (102-mm) unit with 2-1/2-inch (64-mm), red LED digital display for hours and minutes and 1-5/16-inch (33-mm) display for seconds; a separately mounted, mode-control switch; and the following features:
   a. Display Visibility: Hour and minute numerals readable at 30 feet (10 m) in normal ambient light.
   b. Operating Modes:
      1) Normal: Clock operates as a regular secondary system clock, displaying corrected time in normal display configuration, selectable between 12- and 24-hour formats, with "PM" digital display for 12-hour format.
      2) Count-Down or Count-Up Timer: Selected by mode-control switch count-up and count-down positions, and capable of being preset at the mode-control station.
      3) Code Blue: Automatically selected by a signal through a wiring connection from the code-blue system. This signal captures control of the clock regardless of current mode or correction status and instantly initiates count-up operation, starting at time 00:00:00. While in this mode, other clock functions, including correction, shall run in

the background. Clock shall revert to normal operating mode when the initiating-signal system is reset.

c. Mode-Selector Switch: Push-button or rotary, multiposition type, flush mounted; with start, stop, and reset capability in both count-up and count-down modes.

d. Audible tone signal: Housed in clock or mode-selector-switch box. Sounds at end of preset up or down count.

4. Provision for Modular Panel Installation: Equip designated clock for panel mounting. Mount flush or semirecessed with arrangement and trim as indicated. Coordinate wiring with other modular panel components, including room lighting switches **OR** intercom devices **OR** convenience outlets **OR** data outlets **OR** speaker **OR** other similar devices, **as directed**.

5. Provision for Time-Tone-Unit Installation: Equip indicated clocks for housing or mounting in an acoustically treated and baffled speaker compartment specified in Division 27 Section "Public Address And Mass Notification Systems".

D. Secondary Indicating Clock Characteristics:

a. Clock Type: Analog **OR** Digital, **as directed**.

b. Face Configuration: Single **OR** Double, **as directed**.

c. Mounting: Recessed **OR** Semirecessed **OR** Pendant **OR** Surface **OR** Suspended **OR** Within time-tone unit **OR** Within modular panel, **as directed**.

d. Nominal Dimensions: as directed by the Owner.

e. Casing Finish: Types and colors, as directed by the Owner.

f. Special Environmental Conditions: Describe conditions such as corrosive, damp, or wet locations, as directed by the Owner.

g. For analog clocks.

1) Dial Face Color: as directed by the Owner.

2) Analog Clock Crystal: Clear glass **OR** acrylic **OR** polycarbonate, **as directed**.

h. For digital clocks.

1) Face Color: as directed by the Owner.

2) Display Height: as directed by the Owner.

3) Seconds Display: Yes **OR** No, **as directed**.

4) Digital Clock Lens: Antiglare acrylic material.

5) Battery Backup: Yes **OR** No, **as directed**.

6) Interval-Timer Display: Yes **OR** No, **as directed**.

E. Program Signal Devices

1. Bells: Heavy-duty, modular, vibrating type with the following sound-output ratings measured at 10 feet (3 m):

a. 4-Inch (100-mm) Bell: 90 dB.

b. 6-Inch (150-mm) Bell: 95 dB.

c. 10-Inch (250-mm) Bell: 104 dB.

2. Chimes: Heavy-duty, modular, vibrating chimes with polished-chrome tone bar and enamel-finished housing. Minimum sound-output rating measured at 10 feet (3 m) shall be 75 dB.

3. Clock Buzzers: Adjustable output signal device designed for mounting within clock housing or outlet box.

a. Sound-Output Rating Measured at 3 Feet (1 m): 75 dB.

b. Audible Tone Frequency: Manufacturer's standard between 120 Hz and 2 kHz.

4. Horns: Modular, adjustable-output, vibrating type with minimum full-intensity-rated sound output of 103 dB measured at 10 feet (3 m).

5. Projector Horns: Adjustable-output, vibrating type with single **OR** double, **as directed**, projector arranged to channel sound in the direction of the projector axis, and with minimum full-intensity-rated sound output of 104 dB measured at 10 feet (3 m).

6. Loudspeakers for Audible Tones: See Division 27 Section "Public Address And Mass Notification Systems".

7. Visible Signal Devices: Strobe lights with blue **OR** yellow, **as directed**, polycarbonate lens and xenon flash tube, with lens mounted on an aluminum faceplate and the word "Program" engraved

in letters at least 1 inch (25 mm) high on lens. Lamp unit shall have a minimum rated light output of 75 candela.

8. Combination Audible and Visible Signal Devices: Factory-integrated horn and strobe light in a single mounting assembly.
9. Outdoor Signal Equipment: Weatherproof models listed for outdoor use.
10. Mounting Arrangement for Signal Devices: Designed for attachment with screws on the mounting plate of a flush-mounted back box unless otherwise indicated.
11. Enclosures for Flush-Mounting Bells and Horns: Enclosure, mounting plate, and grille assembly shall be furnished by device manufacturer to match features of the device to be mounted. Enclosure shall be recessed in wall, completely enclosing the device, with grille mounting over the open side of the enclosure and flush with the wall.
12. Connection Provision for Signal-Indicating Devices: Plug connector **OR** Wire pigtail or compression splice, **as directed**.

F. Clock Circuit Power Booster
1. Description: Transformer power supply, mounted in steel cabinet with hinged door, and having fuse-protected input and output circuits.

G. Back Boxes For Secondary Indicating Clocks And Program Devices
1. Description: Box and cover-plate assembly shall be furnished by device manufacturer and be suitable for device to be mounted. Back boxes shall be equipped with knockouts and hanger straps or mounting adapters arranged for flush mounting the device unless otherwise indicated.

H. Guards
1. Description: Formed-steel wire, shaped to fit around guarded device, with 1-inch (25-mm) maximum clearance.
   a. Mounting Provisions: Fixed tabs, welded to guard and arranged for screw attachment to mounting surface.
   b. Finish for Indoor Devices: Clear epoxy lacquer over zinc plating.
   c. Finish for Outdoor Devices: Black powder coat over zinc plating and primer.

I. Rack-Mounting Provision For Master Clock
1. Equipment Cabinet: Floor **OR** Wall, **as directed**,-mounted, rack type. Comply with EIA-310-D and the following:
   a. Cabinet Housing: Constructed of steel, with front and rear, **as directed**, doors; with manufacturer's standard tumbler locks, keyed alike.
      1) Front door shall have a clear panel in front of the master clock display.
      2) Housing shall enclose master clock and auxiliary clock system components, plus a minimum of 20 percent spare capacity for future equipment.
   b. Forced Ventilation: Internal low-noise fan with a filtered intake vent, connected to operate from 105- to 130-V ac, 60 Hz; separately fused and switchable and arranged to be powered when main cabinet power switch is on.
      OR
      Natural Ventilation: Ventilated rear and sides with louvers and solid top.
   c. For freestanding, floor-mounting cabinet, arrange inputs, outputs, interconnections, and test points so they are accessible at rear of rack for maintenance and testing, with each item removable from rack without disturbing other items or connections.
   d. Blank Panels: Cover empty space in equipment racks so entire front of rack is occupied by equipment or panels.
   e. Finish: Uniform, baked-enamel, manufacturer's standard color finish over rust-inhibiting primer.
   f. Power-Control Panel: On front of equipment housing; with master power on-off switch and pilot light, and socket for a 5-A, indicating, cartridge fuse for rack equipment power.
   g. Vertical Plug Strip: Grounded receptacles, 12 inches (300 mm) o.c. the full height of rack, to supply rack-mounting equipment.

h. Maintenance Receptacles: Duplex convenience outlet with supply terminals separate from equipment plug strip and located in front of rack.

J. Conductors And Cables
1. Conductors: Jacketed, twisted pair and twisted multipair, untinned solid copper. Sizes as recommended by system manufacturer, but not smaller than No. 22 AWG. Voltage drop for signal, control, and clock correction circuits shall not exceed 10 percent under peak load conditions. Comply with requirements in Division 27 Section "Communications Horizontal Cabling".
2. 120-V AC and Class 1 Signal and Control Circuits: Stranded, single conductors of size and type recommended by system manufacturer. Materials and installation requirements are specified in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
3. Class 2 and Class 3 Signal and Control Circuits: Single conductor or twisted-pair cable, unshielded, unless manufacturer recommends shielded cable.
4. Data Circuits: Category 6 minimum, unshielded, twisted-pair cable, unless manufacturer recommends shielded cable.
5. Insulation: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.
6. Plenum Cable: Listed and labeled for plenum installation.
7. Conductor Color-Coding: Uniformly identified and coordinated with wiring diagrams.
8. Shielding: For speaker-microphone leads and at other locations recommended by manufacturer; No. 34 AWG tinned, soft-copper strands formed into a braid or equivalent foil.
a. Minimum Shielding Coverage on Conductors: 60 percent.

K. Pathways
1. Intercommunication and Program System Raceways and Boxes: Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems".
OR
Intercommunication and Program System Raceways and Boxes: Same as required for electrical branch circuits specified in Division 26 Section "Raceway And Boxes For Electrical Systems".
OR
Intercommunication and Program System Raceways and Boxes: Optical fiber/communications raceway and fittings **OR** Metal wireways **OR** Nonmetal wireways **OR** Surface metal raceways **OR** Surface nonmetal raceways, **as directed**.
2. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.
3. Flexible metal conduit is prohibited.

1.3 EXECUTION

A. Installation
1. Mount system components with fastening methods and devices designed to resist the seismic forces indicated in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".

B. Wiring Methods
1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
a. Install plenum cable in environmental air spaces, including plenum ceilings.
b. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway And Boxes For Electrical Systems".
OR
Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

2. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
3. Support cables not enclosed in raceways on J-Hooks. Install, size, and space J-Hooks to comply with TIA/EIA-568-B.

C. Electrical Connections
1. Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
2. Use plug connectors **OR** splices, **as directed**, for connections to clocks and signal devices.
3. Ground clocks, programming equipment, and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

D. Identification
1. Comply with Division 26 Section "Identification For Electrical Systems".
2. Color-code wires, and apply wire and cable marking tape to designate wires and cables so they are uniformly identified and coordinated with wiring diagrams throughout the system.

E. Field Quality Control
1. Perform tests and inspections.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
   a. Perform operational-system tests to verify compliance with the Specifications and make adjustments to bring system into compliance. Include operation of all modes of clock correction and all programming and manually programmed signal and relay operating functions.
   b. Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
3. Clock system will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

F. Adjusting
1. Program system according to the Owner's requirements. Set system so signal devices operate on the Owner-required schedules and are activated for durations selected by the Owner. Program equipment-control output circuits to suit the Owner's operating schedule for equipment controlled.
2. Adjust sound-output level of adjustable signal devices to suit the Owner's requirements.
3. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

G. Demonstration
1. Train the Owner's maintenance personnel to adjust, operate, and maintain clock-and-program-control system components.

END OF SECTION 27 53 13 13

Task	Specification	Specification Description
27 53 13 16	27 53 13 13	Clock And Program Control

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SECTION 28 16 11 00 - PERIMETER SECURITY

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for perimeter security. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Perimeter detection and alarm system.
b. Integration of other electronic and electrical systems and equipment.

C. Definitions
1. CCTV: Closed-circuit television.
2. EMI: Electromagnetic interference.
3. PIR: Passive infrared.
4. RFI: Radio-frequency interference.
5. UPS: Uninterruptible power supply.
6. Control Unit: System component that monitors inputs and controls outputs through various circuits.
7. Master Control Unit: System component that accepts inputs from other control units and may also perform control-unit functions. The unit has limited capacity for the number of protected zones and is installed at an unattended location or at a location where it is not the attendant's primary function to monitor the security system.
8. Monitoring Station: Facility that receives signals and has personnel in attendance at all times to respond to signals. A central station is a monitoring station that is listed.
9. Protected Zone: A protected premises or an area within a protected premise that is provided with means to prevent an unwanted event.
10. Standard Intruder: A person who weighs 100 lb (45 kg) or less and whose height is 60 inches (1525 mm) or less; dressed in a long-sleeved shirt, slacks, and shoes unless environmental conditions at the site require protective clothing.
11. Standard-Intruder Movement: Any movement, such as walking, running, crawling, rolling, or jumping, of a "standard intruder" in a protected zone.
12. Systems Integration: The bringing together of components of several systems containing interacting components to achieve indicated functional operation of combined systems.
13. Zone. A defined area within a protected premise. It is a space or area for which an intrusion must be detected and uniquely identified. The sensor or group of sensors must then be assigned to perform the detection, and any interface equipment between sensors and communication must link to master control unit.

D. Action Submittals
1. Product Data: Components for sensing, detecting, systems integration, and control, including dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
2. Shop Drawings: Detail assemblies of standard components that are custom assembled for specific application on this Project.
a. Functional Block Diagram: Show single-line interconnections between components including interconnections between components specified in this Section and those furnished under other Sections. Indicate methods used to achieve systems integration. Indicate control, signal, and data communication paths and identify programmable logic controllers **OR** networks, **as directed,** and control interface devices and media to be used. Describe characteristics of network and other data communication lines.

1) Indicate methods used to achieve systems integration.
2) Indicate control, signal, and data communication paths and identify PLCs, networks, control interface devices, and media to be used.
3) Describe characteristics of network and other data communication lines.
4) Describe methods used to protect against power outages and transient voltages including types and ratings of isolation and surge suppression devices used in data, communication, signal, control, and ac and dc power circuits.

b. Raceway Riser Diagrams: Detail raceway runs required for perimeter security and for systems integration. Include designation of devices connected by raceway, raceway type, and size, and type and size of wire and cable fill for each raceway run.
c. UPS: Sizing calculations.
d. Site and Floor Plans: Indicate final outlet and device locations, routing of raceways, and cables inside and outside the building. Include room layout for central-station control-unit console, terminal cabinet, racks, and UPS.
e. Master Control Unit Console Layout: Show required artwork and device identification.
f. Device Address List: Coordinate with final system programming.
g. System Wiring Diagrams: Include system diagrams unique to Project. Show connections for all devices, components, and auxiliary equipment. Include diagrams for equipment and for system with all terminals and interconnections identified.
h. Details of surge-protection devices and their installation.
i. Sensor detection patterns and adjustment ranges.

3. Equipment and System Operation Description: Include method of operation and supervision of each component and each type of circuit. Show sequence of operations for manually and automatically initiated system or equipment inputs. Description must cover this specific Project; manufacturer's standard descriptions for generic systems are not acceptable.
4. Samples for Initial Selection: For units with factory-applied color finishes.
5. Samples for Verification: For each type of exposed finish required.

E. Informational Submittals
1. Qualification Data: For Installer, security systems integrator, and testing agency.
2. Field quality-control test reports.
3. Warranty: Sample of special warranty.
4. Other Information Submittals:
a. Test Plan and Schedule: Test plan defining all tests required to ensure that system meets technical, operational, and performance specifications within 60 days of date of Contract award.
b. Examination reports documenting inspections of substrates, areas, and conditions.
c. Anchor inspection reports documenting inspections of built-in and cast-in anchors.

F. Closeout Submittals
1. Operation and Maintenance Data: For perimeter security system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation And Maintenance Data", include the following:
a. Data for each type of product, including features and operating sequences, both automatic and manual.
b. Master control-unit hardware and software data.

G. Maintenance Material Submittals
1. One spare control-unit board(s) for strain-sensitive cable system and one cable repair and splice kit(s).
2. One of each type of microwave sensor and one of each type of power supply for microwave perimeter security system.
3. One of each spare sensor and PIR unit and one alignment telescope(s) for long-range PIR system.
4. One spare control-unit board(s) for electrostatic-field system.

5. One spare control-unit board(s) for buried, ported coaxial cable system, 10 feet (3 m) of cable; and one cable repair and splice kit(s).
6. Fuses: Three of each kind and size.
7. Tool Kit: Provide six sets of tools for use with security fasteners, each packaged in a compartmented kit configured for easy handling and storage.
8. Security Fasteners: Furnish no fewer than 1 box for every 50 boxes or fraction thereof, of each type and size of security fastener installed.

H. Quality Assurance
1. Installer Qualifications:
   a. An employer of workers, at least one of whom is a technician certified by the National Burglar & Fire Alarm Association.
   b. Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Security Systems Integrator Qualifications: An experienced perimeter security equipment supplier and Installer who has completed systems integration work for installations similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.
3. Testing Agency Qualifications: Member company of NETA or an NRTL.
   a. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. FMG Compliance: FMG-approved and -labeled perimeter security devices and equipment.
6. Comply with NFPA 70.

I. Project Conditions
1. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
   a. Altitude: Sea level to 4000 feet (1220 m).
   b. Master Control Unit: Rated for continuous operation in an ambient of 60 to 85 deg F (16 to 29 deg C) and a relative humidity of 20 to 80 percent, noncondensing.
   c. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambients of minus 30 to plus 122 deg F (minus 34 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, condensing. Comply with UL 294 and UL 639 for outdoor-use equipment. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h) and snow cover up to 24 inches (610 mm) thick.
   d. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings shall be rated, listed, and installed according to NFPA 70.

J. Warranty:
1. Special Warranty: Manufacturer's standard form in which manufacturer and Installer agree to repair or replace components of perimeter security devices and equipment that fail in materials or workmanship within specified warranty period.
   a. Warranty Period: Two years from date of Final Completion.

1.2 PRODUCTS

A. Functional Description Of System
1. Description: Perimeter protection system with fence-mounted systems **OR** buried sensors **OR** volumetric detectors, **as directed,** integrated into a single perimeter detection and alarm system.
2. Supervision: System components shall be continuously monitored for normal, alarm, supervisory and trouble conditions. Indicate deviations from normal conditions at any location in

system. Indication includes identification of device or circuit in which deviation has occurred and whether deviation is an alarm or malfunction.

a. Alarm Signal: Display at central-station control unit and actuate audible and visual alarm devices.
b. Trouble Condition Signal: Distinct from other signals, indicating that system is not fully functional. Trouble signal shall indicate system problems such as battery failure, open or shorted transmission line conductors, or controller failure.
c. Supervisory Condition Signal: Distinct from other signals, indicating an abnormal condition as specified for the particular device or controller.

3. System Control: Central-station control unit shall directly monitor gate detection devices, perimeter detection units, and connecting wiring.

OR

System Control: One or more remote, addressable controllers operate under control of a central-station control-unit microcomputer in a multiplexed distributed control system or as part of a network. Controllers shall receive programming by multiplexed signal transmission from a central-station control-unit microprocessor or microcomputer and hold data in nonvolatile memory. System shall automatically reboot program without error or loss of status or alarm data after any system disturbance, **as directed**.

4. Operator Commands:
   a. Help with System Operation: Display all commands available to operator. Help command, followed by a specific command, shall produce a short explanation of the purpose, use, and system reaction to that command.
   b. Acknowledge Alarm: To indicate that alarm message has been observed by operator.
   c. Place Protected Zone in Access: Disable all intrusion-alarm circuits of a specific protected zone. Tamper circuits may not be disabled by operator.
   d. Place Protected Zone in Secure: Activate all intrusion-alarm circuits of a protected zone.
   e. Protected Zone Test: Initiate operational test of a specific protected zone.
   f. System Test: Initiate system-wide operational test.
   g. Print Reports.
5. Timed Control at Central-Station Control Unit: Allow automatically timed "secure" and "access" functions of selected protected zones.
6. Automatic Control of Related Systems: Alarm or supervisory signals from certain perimeter security devices control the following functions in related systems:
   a. Switch selected lights.
   b. Open a signal path between certain intercommunication stations.
   c. Shift sound system to "listening mode" and open a signal path to certain system speakers.
   d. Switch signal to selected monitor from closed-circuit television camera in vicinity of sensor signaling an alarm.
7. Printed Record of Events: Print a record of alarm, supervisory, and trouble events on system printer. Sort and report by protected zone, device, and function. When central-station control unit receives a signal, print a report of alarm, supervisory, or trouble condition. Report type of signal (alarm, supervisory, or trouble), protected zone description, date, and time of occurrence. Differentiate alarm signals from other indications. When system is reset, report reset event with the same information concerning device, location, date, and time. Commands shall initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.
8. Response Time: Two seconds between actuation of any alarm and its indication at central-station control unit.
9. Circuit Supervision: Supervise all signal and data transmission lines, links with other systems, controllers, and sensors from central-station control unit. Indicate circuit and detection device faults with both protected zone and trouble signals, sound a distinctive audible tone, and illuminate an LED. Maximum permissible elapsed time between occurrence of a trouble condition and indication at central-station control unit is 20 seconds. Initiate an alarm in response to opening, closing, shorting, or grounding of a signal or data transmission line.

10. Programmed Secure-Access Control: System shall be programmable to automatically change status of various combinations of protected zones between secure and access conditions at scheduled times. Status changes may be preset for repetitive, daily, and weekly; specially scheduled operations may be preset up to a year in advance. Manual secure-access control stations shall override programmed settings.
11. Manual Secure-Access Control: Coded entries at manual stations shall change status of associated protected zone between secure and access conditions.

B. System Component Requirements
1. Compatibility: Detection devices and their communication features, connecting wiring, and master control unit shall be selected and configured with accessories for full compatibility with the existing equipment.
2. Perimeter Security Units: Listed and labeled by a qualified testing agency for compliance with UL 639.
3. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor entry connection to components.
   a. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits".
   b. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits" as recommended by manufacturer for type of line being protected.
4. Interference Protection: Components shall be unaffected by radiated RFI and electrical induction of 15 V/m over a frequency range of 10 to 10,000 MHz and conducted interference signals up to 0.25-V RMS injected into power supply lines at 10 to 10,000 MHz.
5. Tamper Protection: Tamper switches on detection devices, controllers, annunciators, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled and when entering conductors are cut or disconnected. Central-station control-unit alarm display shall identify tamper alarms and indicate locations.
6. Self-Testing Devices: Automatically test themselves periodically, but not less than once per hour, to verify normal device functioning and alarm initiation capability. Devices transmit test failure to central-station control unit.
7. Antimasking Devices: Automatically check operation continuously or at intervals of a minute or less, and use signal-processing logic to detect blocking, masking, jamming, tampering, or other operational dysfunction. Devices transmit detection of operational dysfunction to central-station control unit as an alarm signal.
8. Addressable Devices: Transmitter and receivers shall communicate unique device identification and status reports to central-station control unit.
9. Remote-Controlled Devices: Individually and remotely adjustable for sensitivity and individually monitored at central-station control unit for calibration, sensitivity, and alarm condition.

C. Enclosures
1. Interior Sensors: Enclosures that protect against dust, falling dirt, and dripping noncorrosive liquids.
2. Interior Electronics: NEMA 250, Type 12.
3. Exterior Electronics: NEMA 250, Type 4X fiberglass **OR** stainless steel, **as directed**.
4. Corrosion Resistant: NEMA 250, Type 4X PVC **OR** stainless steel, **as directed**.
5. Terminal cabinets in handholes and manholes shall be NEMA 250, Type 6 **OR** 6P, **as directed**.
6. Screw Covers: Where enclosures are accessible to inmates, secure with security fasteners of type appropriate for enclosure.

D. Secure And Access Devices
1. Keypad and Display Module: Arranged for entering and executing commands for system-status changes and for displaying system-status and command-related data.

2. Key-Operated Switch: Change protected zone between secure and access conditions.

E. Strain-Sensitive Cable
1. Description: Strain-sensitive, coaxial transducer cable shall monitor chain-link-type and welded-mesh-type fence and generate an alarm when a standard intruder attempts to climb over, cut through, or lift fence fabric.
2. Environment: Suitable for exterior installation and the following conditions:
   a. Ambient Temperatures: Ranging from minus 22 to plus 158 deg F (minus 30 to plus 70 deg C).
3. Transducer Cable:
   a. Ultraviolet-resistant cable furnished by system manufacturer.
   b. Suitable for up to 1000 feet (300 m) of sensor cable per single-zone controller and up to 2000 feet (600 m) of sensor cable per dual-zone processor.
   c. Sensitivity shall be uniform throughout its entire length, requiring only one variable sensitivity adjustment throughout its entire length.
4. Control Unit:
   a. Field mounted, with tamper switch at controller board.
   b. Electronic circuitry shall discriminate between acceptable fence movement and intrusion-related disturbances.
   c. Sensitivity, count control, and climb-over processors shall be adjustable with a minimum of five individual count-control and climb-over adjustments.
   d. Controller output shall have adjustable pulse width to adjust the time the alarm relay will activate per detected intrusion attempt.
5. System Performance:
   a. Immune to RFI and EMI environments; interference shall have no effect on normal operational characteristics.
   b. Trouble and Tamper: Entire sensor system shall be fully supervised with individually monitored tamper and supervision alarms. Disconnecting, cutting, or shorting of strain-sensitive cable results in supervisory alarm.
   c. Intrusion Simulation: Each zone shall have a self-test feature that, when activated by a signal from central-station control unit, will produce an intrusion alarm and verify operation of sensor.

F. Microwave Intrusion Detectors
1. Description: Volumetric microwave detection system.
2. Device Performance: Microwave transmitter establishes an electromagnetic field in an adjustable detection pattern and detects intrusion by monitoring changes in that pattern.
   a. Movement Sensitivity: Adjustable, able to detect standard-intruder movement within sensor's detection pattern at any speed between 0.1 to 50 fps (0.03 to 15.2 m/s). Sensor sensitivity adjustments shall be accessible only when sensor housing is removed, and sensors shall comply with 47 CFR 15.
   b. Detection range: 15 to 600 feet (5 to 180 m).
   c. Range Sensitivity: Adjustable for setting area of protection between 15 to 500 feet (5 to 152 m) in range and from 2 to 40 feet (0.6 to 12 m) in beam diameter.
   d. Trouble and Tamper: Fully supervised with individually monitored tamper and supervision alarms. System failure shall result in tamper alarm. System jamming or wrong modulation shall result in supervisory alarm.
   e. Activation Indicator: LED indicator shall not be visible during normal operation. Indicator shall light when sensor detects a standard intruder. Locate test-enabling switch under sensor housing cover.
   f. Remote Test: When initiated by central-station control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.
3. Environment: Suitable for exterior installation and the following conditions:

a. Ambient Temperatures: Ranging from minus 30 to plus 158 deg F (minus 34 to plus 70 deg C) and in rainfall up to 4 inches (100 mm).

G. Electrostatic Field
1. Description: Electronically balanced phase electrostatic-field detection system consisting of a field generator that generates an electrical field in one or more field wires and that has two or more sensing wires, a sense filter, amplifier, and a controller. Detection fields shall have a minimum of four different frequencies so adjacent zones cannot interfere with each other.
2. Environment: Suitable for exterior installation and the following conditions:
   a. Ambient Temperatures: Ranging from minus 22 to plus 158 deg F (minus 30 to plus 70 deg C).
3. System Performance:
   a. Detect, via sense wires, a compound signal form consisting of amplitude change, rate of change, and pre-set time disturbance that forms a "signature" of human movement. Generate an alarm when all exist simultaneously. Provide detection fields of not less than four different frequencies so adjacent zones do not interfere with each other.
   b. Control Units: Single or multiple zone, with sense filter. Front panel with calibration meter, status of alarm transmitter, sensitivity selector, test point selector, power indicator, and power control. Control unit shall reject signals due to wind and small objects striking the wires.
   c. Motion Detection: Sense standard-intruder movement at rates from 0.15 to 26 fps (0.045 to 8.0 m/s).
   d. Zone Length: Not to exceed 500 feet (152 m) **OR** 325 feet (100 m), **as directed**.
   e. Supervision: Generate trouble signal if field or sense wires are cut or shorted to ground or to each other. Generate supervisory alarm if received signal is substantially reduced.
4. Insulators, Wire-Tensioning Devices, and Brackets: Manufacturer's standard for mounting and tensioning of wires.
5. Field and Sensing Wires: Stainless steel.

H. Buried, Ported Coaxial Cable
1. Description: Buried electrostatic-field detection system consisting of parallel, ported coaxial cables that generate a detection field between cables.
2. Environment: Suitable for exterior installation and the following conditions:
   a. Ambient Temperatures: Ranging from minus 22 to plus 158 deg F (minus 30 to plus 70 deg C).
3. System Performance: One of two parallel cables receives a continuous wave signal from a transmitter module. Second cable, connected to a sensor module, detects, preamplifies, and analyzes variations in signal. When system senses "signature" of a standard intruder in the detection zone, based on mass, motion, and time of day, it generates an alarm.
   a. Transmitter: Locate at one end of zone, with standby battery.
   b. Preamplifier-Sensor: Locate at opposite end from transmitter, with standby battery.
   c. Front panel with sensitivity calibration meter, calibrated self-test potentiometer, power switch, and LED normal and malfunction indicators.
   d. Electromagnetic Radiation: Less than 50 mV per meter at 30 m.
   e. Motion Detection: Sense standard-intruder movement at rates from 0.17 to 26 fps (0.05 to 8.0 m/s).
   f. Zone Length: Not to exceed 500 feet (152 m) **OR** 325 feet (100 m), **as directed**.
   g. Zone Width: Not to exceed 15 feet (4.6 m), with an average width of 12 feet (3.7 m).
   h. Zone Height: Approximately 3.3 feet (1.0 m), depending on sensitivity setting.
   i. Supervision: Generate trouble signal if cable is cut or shorted to ground. Generate supervisory alarm if cabinets are tampered with.
4. Enclosures: Hinged cover with tamper switch and security fasteners.
5. Buried, Ported Coaxial Cable: Approximately 1/2-inch (1.3-mm) diameter, minimum 10 AWG center conductor, foam polyethylene dielectric, braided copper outer conductor, and polyethylene jacket.

I. Long-Range PIR Detectors
1. Description: Volumetric passive infrared detection system.
2. Listed and labeled by a qualified testing agency for compliance with SIA PIR-01.
3. Environment: Suitable for exterior installation and the following conditions:
   a. Ambient Temperatures: Ranging from minus 30 to plus 150 deg F (minus 34 to plus 65 deg C).
4. System Performance: Detect an interruption of dual-infrared light beams that link transmitters and receivers. Generate an alarm when signal is interrupted due to presence of an object that interrupts both beams.
   a. Sensitivity: Field adjustable to allow adjustment of range from 25 to 500 feet (7.6 to 152 m), generating an alarm within 20 to 50 ms when both beams are interrupted.
   b. Detection system shall adjust automatically to compensate for weather, including fog, rain, snow, blowing dust, and rapid temperature changes.
   c. Motion Detection: Detect standard-intruder movement at rates from 0.1 to 50 fps (0.03 to 15.2 m/s).
   d. Supervision: Generate supervisory alarm if any portion of system is tampered with.
   e. Remote Test: When initiated by central-station control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

J. Geophone Fence Detection
1. Description: Fence-mounted system to detect attempts to cut or climb the protected fence, using geophone sensors that respond to specific shock or vibrations.
2. Environment: Suitable for exterior installation and the following conditions:
   a. Ambient Temperatures: Ranging from minus 30 to plus 150 deg F (minus 34 to plus 65 deg C).
3. System Performance:
   a. Controller: 10 zone capacity for processing geophone generated analog signals. Each zone shall consist of not more than 10 sensors.
      1) Adjustments: For each zone provide stepped gain control for sensitivity, and switches for geophone signal filters to minimize nuisance alarms. System shall adjust automatically to compensate for weather, including fog, rain, snow, blowing dust, and rapid temperature changes.
      2) Trouble Condition Signal: Generate when any zone fails.
      3) Supervisory Condition Signal: Generate on interference with controller operation or when detecting a break-in into a enclosure housing electronics.
   b. Sensors: Fence mounted 20 feet (6 m) o.c.
   c. Cable for Interconnection of System Components: Shielded, PVC jacketed and armored, as supplied by system manufacturer.
   d. Test each zone simulating an alarm condition. Test by command from central-station control **OR** test switch at controller inside the enclosure, **as directed**.

K. Video Motion Sensor
1. Description: Video-surveillance based detection system.
2. Device Performance: Detect changes in video signal within a user-defined protected zone. Provide an alarm output for each video input.
   a. Detect movement within protected zone of standard intruders wearing clothing with a reflectivity that differs from that of background scene by a factor of 2. Reject all other changes in video signal.
   b. Modular design that allows for expansion or modification of number of inputs.
   c. Adjustable Controls:
      1) Number of detection zones.
      2) Size of detection zones.
      3) Sensitivity of detection of each protected zone.
   d. Mounting: Standard 19-inch (480-mm) rack as described in EIA 310.

3. Environment: Suitable for installation in interior air-conditioned spaces.

L. Gate Units
1. Description: Fence mounted gate-movement detector, blanced-magnetic type, UL listed for outdoor locations. Units shall be designed for mounting on single- or double-leaf swinging or rolling gates and have armored jumper cables between switch and stationary junction box for wiring to central-station control unit and tamper switches in junction box.
2. Device Performance: Bias magnet and at least three encapsulated-reed switches that resist compromise from introduction of foreign magnetic fields, with integral overcurrent protective device to limit current to 80 percent of switch capacity.
3. Remote Test: Simulate movement of actuating magnet from central-station control unit.

M. Field-Mounted Control Units
1. Field-mounted control units shall include the power supply and detector specific functions, and provide for communications with the master control unit. Control unit shall include read-only resident software needed for startup, a time clock, and all automatic operations. Software shall be downloaded from the master control unit.
2. Battery Backup: UPS, providing 6 hours of run time during a power outage, with 2-rate automatic battery charger to fully recharge batteries within 12 hours after normal power is restored.
   a. Batteries: Rechargeable, valve-regulated, recombinant, sealed, lead-acid type with nominal 10-year life expectancy.
   b. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Charger shall recharge fully discharged battery within 24 hours.
3. Annunciation: Indicate a change in system condition and switching of system or component to backup power.

N. Master Control Unit
1. Description: Supervise sensors and detection subsystems and their connecting communication links, status control (secure or access) of sensors and detector subsystems, activation of alarms and supervisory and trouble signals, and other indicated functions.
   a. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
   b. Include a real-time clock for time annotation of events on the event recorder and printer.
   c. Addressable initiation devices that communicate device identity and status.
   d. Control circuits for operation of mechanical equipment in response to an alarm.
2. Construction: Freestanding equipment rack **OR** Desk-mounted console, **as directed,** modular, with separate and independent alarm and supervisory system modules. Alarm-initiating protected zone boards shall be plug-in cards. Arrangements that require removal of field wiring for module replacement are unacceptable.
3. Comply with UL 609 **OR** UL 681 **OR** UL 1076, **as directed**.
4. Console Controls and Displays: Arranged for interface between human operator at master control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
   a. Annunciator and Display: LCD type, one **OR** two **OR** three line(s) of 40 **OR** 80 characters, minimum, **as directed**.
   b. Keypad: Arranged to permit entry and execution of programming, display, and control commands
   c. Control-Unit Network: Automatic communication of alarm, status changes, commands, and other communications required for system operation. Communication shall return to normal after partial or total network interruption such as power loss or transient event. Total or partial signaling network failures shall identify the failure and record the failure at the annunciator display and at the system printer.
   d. Field Device Network: Communicate between the control unit and field devices of the system. Communications shall consist of alarm, network status, and status and control of

field-mounted processors. Each field-mounted device shall be interrogated during each interrogation cycle.

e. Operator Controls: Manual switches and push-to-test buttons that do not require a key to operate. Prevent resetting of alarm, supervisory, or trouble signals while alarm or trouble condition persists. Include the following:
   1) Acknowledge alarm.
   2) Silence alarm.
   3) System reset.
   4) LED test.

f. Timing Unit: Solid state, programmable, 365 days.

g. Confirmation: Relays, contactors, and other control devices shall have auxiliary contacts that provide confirmation signals to system for their on or off status. Software shall interpret such signals, display equipment status, and initiate failure signals.

h. Alarm Indication: An audible signal sounds and an LED lights at master control unit identifying the protected zone **OR** addressable detector, **as directed,** originating the alarm. Annunciator panel displays a common alarm light and sounds an audible tone.

i. Alarm Indication: An audible signal sounds and a plain-language identification of the protected zone **OR** addressable detector, **as directed** originating the alarm appears on LED or LCDdisplay at master control unit. Annunciator panel displays a common alarm light and sounds an audible tone.

j. Alarm Indication: An audible signal sounds and a plain-language identification of the protected zone **OR** addressable detector, **as directed** originating the alarm appears on LED, LCD or cathode-ray-tube display, **as directed** at master control unit. Annunciator panel alarm light and audible tone identify protected zone signaling an alarm.

k. Alarm activation sounds a bell **OR** siren **OR** strobe **OR** bell or siren and strobe, **as directed**.

5. Protected Zones: Quantity of alarm and supervisory zones as indicated, with capacity for expanding number of protected zones by a minimum of 25 percent.

6. Power Supply Circuits: Master control units shall provide power for remote power-consuming detection devices. Circuit capacity shall be adequate for at least a 25 percent increase in load.

7. UPS: Comply with Division 26 Section "Static Uninterruptible Power Supply". UPS shall be sized to provide a minimum of six hours of master control-unit operation.

8. Cabinet: Lockable, steel enclosure arranged so operations required for testing, normal operation, and maintenance are performed from front of enclosure. If more than a single cabinet is required to form a complete control unit, provide exactly matching modular enclosures. Accommodate all components and allow ample gutter space for field wiring. Identify each enclosure by an engraved, laminated, phenolic-resin nameplate. Lettering on enclosure nameplate shall not be less than 1 inch (25 mm) high. Identify, with permanent labels, individual components and modules within cabinets.

9. Transmission to Monitoring Station: A communications device to automatically transmit alarm, supervisory, and trouble signals to the monitoring station, operating over a standard voice grade telephone leased line. Comply with UL 1635.

10. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

O. Audible And Visual Alarm Devices

1. Bell: UL listed, 10 inches (254 mm) in diameter, rated to produce a minimum sound output of 84 dB at 10 feet (3 m) from central-station control unit.

   a. Enclosure: Weather-resistant steel box equipped with tamper switches on cover and on back of box.

2. Klaxon Weatherproof Motor-Driven Hooter: UL listed, rated to produce a minimum sound output of 120 dB at 3 feet (1 m), plus or minus 3 dB, at a frequency of 470 Hz. Rated for intermittent use - two minutes on, five minutes off.
   a. Designed for use in industrial areas and in high noise, severe weather marine environments.
3. Siren: 30-W speaker with siren driver, rated to produce a minimum sound output of 103 dB at 10 feet (3 m) from central-station control unit.
   a. Enclosure: Weather-resistant steel box with tamper switches on cover and on back of box.
4. Strobe: Xenon light complying with UL 1638, with a clear polycarbonate lens.
   a. Light Output: 115 cd, minimum.
   b. Flash Rate: 60 per minute.

P. Security Fasteners
1. Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator. Drive system type, head style, material, and protective coating as required for assembly, installation, and strength.
2. Drive System Types: Pinned Torx-Plus, pinned Torx, or pinned hex (Allen).
3. Socket Flat Countersunk Head Fasteners:
   a. Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
   b. Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
4. Socket Button Head Fasteners:
   a. Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
   b. Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
5. Socket Head Cap Fasteners:
   a. Heat-treated alloy steel, ASTM A 574 (ASTM A 574M).
   b. Stainless steel, ASTM F 837 (ASTM F 837M), Group 1 CW.
6. Protective Coatings for Heat-Treated Alloy Steel:
   a. Zinc chromate, ASTM F 1135, Grade 3 or 4; for exterior applications and interior applications where indicated.
   b. Zinc phosphate with oil, ASTM F 1137, Grade I, or black oxide, unless otherwise indicated.

Q. Source Quality Control
1. Electrostatic-Field and Buried, Ported Coaxial Cable Systems Electronics: Precondition at factory by subjecting modules to at least 4 days' operational burn-in at temperatures not less than 140 deg F (60 deg C).

1.3 EXECUTION

A. Examination
1. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of perimeter security.
2. Examine roughing-in for embedded and built-in anchors to verify actual locations of perimeter security connections before perimeter security installation.
3. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of perimeter security.
4. Inspect built-in and cast-in anchor installations, before installing perimeter security, to verify that anchor installations comply with requirements. Prepare inspection reports.
   a. Remove and replace anchors where inspections indicate that they do not comply with requirements. Reinspect after repairs or replacements are made.
   b. Perform additional inspections to determine compliance of replaced or additional anchor installations. Prepare inspection reports.
5. For material whose orientation is critical for its performance as a ballistic barrier, verify installation orientation.
6. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Systems Integration
1. Integrate perimeter security system with the following systems and equipment:
   a. Electronic door hardware.
   b. Elevators.
   c. Network lighting controls.
   d. Intercommunications and program systems.
   e. Public address and mass notification systems.
   f. Access control.
   g. Fire-alarm system.
   h. Intrusion detection system.
   i. Video surveillance.

C. System Installation
1. Comply with UL 681 and NFPA 731.
2. Equipment Mounting: Install master control unit on finished floor with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
   a. Comply with requirements for seismic-restraint devices specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
3. Install wall-mounted equipment, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
   a. Comply with requirements for seismic-restraint devices specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
4. Connecting to Existing Equipment: Verify that existing perimeter security system is operational before making changes or connections.
   a. Connect new equipment to existing control panel in existing part of the building.
   b. Connect new equipment to existing monitoring equipment at the Supervising Station.
   c. Expand, modify, and supplement existing **control** or **monitoring** equipment as necessary to extend existing **control** or **monitoring**] functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.
5. Security Fasteners: Where accessible to inmates, install perimeter security components using security fasteners with head style appropriate for fabrication requirements, strength, and finish of adjacent materials except that a maximum of two different sets of tools shall be required to operate security fasteners for Project. Provide stainless-steel security fasteners in stainless-steel materials.
6. Wiring Method: Install power, signal, and data transmission wire and cable in raceways according to Division 26 Section(s) "Underground Ducts And Raceways For Electrical Systems" AND "Raceway And Boxes For Electrical Systems". Minimum conduit size shall be 1/2 inch (13 mm). Control and data transmission wiring shall not share raceways with any other system.
7. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with perimeter security system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
8. Wires and Cables:
   a. Conductors: Size as recommended in writing by system manufacturer, unless otherwise indicated.
   b. 120-V Power Wiring: Install according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables", unless otherwise indicated.
   c. Cable for Low-Voltage Control and Signal Circuits: Install unshielded, twisted-pair cable, unless otherwise indicated or if manufacturer recommends shielded cable, according to Division 28 Section "Conductors And Cables For Electronic Safety And Security".

d. Data and Television Signal Transmission Cables: Install according to Division 28 Section "Conductors And Cables For Electronic Safety And Security"

9. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
10. Install power supplies and other auxiliary components for detection devices at controllers, unless otherwise indicated or required by manufacturer. Do not install such items near devices they serve.
11. Stain-Sensitive Transducer Cable: Attached to fence at 12-inch (300-mm) intervals with tie wraps.
12. Electrostatic-Field System: Install field and sense wires on insulators and standoffs on a fence, wall, or roof. Provide intermediate supports recommended in writing by manufacturer as needed for specified performance.
13. Buried, Ported Coaxial Cable: Transmitters may be located at one end of parallel coaxial cables, and preamplifier-sensor module may be located at opposite end. Install cable so shield is uniform throughout the length, without twisting or distorting cable during installation. Field-cut cables to exact zone length at the site. To attach data transmission cable to sensing cable, use heat-shrink splice kits approved by manufacturer. Provide sufficient overlap of detector cables to eliminate the possibility of entry between zones.

D. Identification
1. Indentify system components wiring, cabling, and terminals. Comply with identification requirements in Division 26 Section "Identification For Electrical Systems".
2. Install instructions frame in a location visible from master control unit.

E. Grounding
1. Ground the master control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to master control unit.
2. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
3. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding. Provide 5-ohm ground. Measure, record, and report ground resistance.
4. Install grounding electrodes of type, size, location, and quantity indicated. Comply with installation requirements in Division 26 Section "Grounding And Bonding For Electrical Systems".

F. Field Quality Control
1. Pretesting: After installation, align, adjust, and balance system and perform complete pretesting to determine compliance of system with requirements in the Contract Documents. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
   a. Report of Pretesting: After pretesting is complete, provide a letter certifying that installation is complete and fully operable; include names and titles of witnesses to preliminary tests.
2. Testing Agency: Engage a qualified testing and inspecting agency to perform tests and inspections.
3. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components and equipment installations, including connections.
4. Tests and Inspections: Comply with provisions in NFPA 731, Ch.9, “Testing and Insptections.”
   a. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
   b. Operational Tests: Schedule tests after pretesting has been successfully completed. Test all modes of system operation and perimeter security at each detection device. Test for detection of intrusion and for false alarms in each protected zone. Test for false alarms by simulating activities outside indicated detection patterns.
   c. Electrical Tests: Comply with NFPA 72, Section A-7. Minimum required tests are as follows:

1) Verify the absence of unwanted voltages between circuit conductors and ground.
2) Test all conductors for short circuits using an insulation-testing device.
3) With each circuit pair, short circuit at the far end of circuit and measure circuit resistance with an ohmmeter. Record circuit resistance of each circuit on Record Drawings.
4) Verify that each controller is in normal condition as detailed in manufacturer's operation and maintenance manual.
5) Test signal and data transmission circuits complying with requirements in Division 28 Section "Conductors And Cables For Electronic Safety And Security" for proper signal transmission under open-circuit conditions. One connection each should be opened at not less than 10 percent of initiating and indicating devices. Observe proper signal transmission according to class of wiring used.
6) Verify that transient surge-protection devices are installed according to manufacturer's written instructions.
7) Test each initiating and indicating device for alarm operation and proper response at central-station control unit.
8) Test both primary and secondary power. Verify, by test, that UPS is capable of operating the system for period and in manner specified.

d. Geophone System Tests: Test each zone at a minimum of two different locations. Test each zone as follows:
1) Horizontal Movement: Adjust sensitivity to screen out alarms from wind.
2) Vertical Climb: 100 percent detection required. Set count at 3 occurrences within 90-second window.
3) Cut Test: 100 percent detection required. Set count at 2 occurrences within 120-second window.
4) Set sensitivity to value as low as possible, consistent with reliable detection.
5) If performance tests fail, make adjustments to sensors to comply with requirements. Retest failing and adjacent zones to comply with test.

e. Strain-Sensitive Cable System Tests: Adjust sensitivity and count control to value as low as possible, consistent with reliable detection.

f. Microwave Perimeter Security System Tests: Adjust sensitivity to value as low as possible, consistent with reliable detection.

g. Long-Range PIR System Tests: Adjust sensitivity and hold time between activity duration to value as low as possible, consistent with reliable detection.

5. Report of Tests and Inspections: Prepare a written record of tests, inspections, and detailed test results in the form of a test log.

6. Tag all equipment, stations, and other components at which tests have been satisfactorily completed.

G. Demonstration

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain perimeter security.

H. Adjusting

1. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose. Visits for this purpose shall be in addition to any required by warranty.

END OF SECTION 28 16 11 00

SECTION 28 16 11 00a - INTRUSION DETECTION

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for intrusion detection. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes:
a. Intrusion detection with communication links to perform monitoring, alarm, and control functions.
2. Integration of other electronic and electrical systems and equipment.

C. Definitions
1. CCTV: Closed-circuit television.
2. PIR: Passive infrared.
3. RFI: Radio-frequency interference.
4. UPS: Uninterruptible power supply.
5. Control Unit: System component that monitors inputs and controls outputs through various circuits.
6. Master Control Unit: System component that accepts inputs from other control units and may also perform control-unit functions. The unit has limited capacity for the number of protected zones and is installed at an unattended location or at a location where it is not the attendant's primary function to monitor the security system.
7. Monitoring Station: Facility that receives signals and has personnel in attendance at all times to respond to signals. A central station is a monitoring station that is listed.
8. Protected Zone: A protected premises or an area within a protected premises that is provided with means to prevent an unwanted event.
9. Standard Intruder: A person who weighs 100 lb (45 kg) or less and whose height is 60 inches (1525 mm) or less; dressed in a long-sleeved shirt, slacks, and shoes unless environmental conditions at the site require protective clothing.
10. Standard-Intruder Movement: Any movement, such as walking, running, crawling, rolling, or jumping, of a "standard intruder" in a protected zone.
11. Systems Integration: The bringing together of components of several systems containing interacting components to achieve indicated functional operation of combined systems.
12. Zone. A defined area within a protected premises. It is a space or area for which an intrusion must be detected and uniquely identified. The sensor or group of sensors must then be assigned to perform the detection, and any interface equipment between sensors and communication must link to master control unit.

D. Action Submittals
1. Product Data: Components for sensing, detecting, systems integration, and control, including dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
2. Show Drawings: Detail assemblies of standard components that are custom assembled for specific application on the Project.
a. Functional Block Diagram: Show single-line interconnections between components including interconnections between components specified in this Section and those furnished under other Sections. Indicate methods used to achieve systems integration. Indicate control, signal, and data communication paths and identify programmable logic controllers **OR** networks, **as directed** and control interface devices and media to be used. Describe characteristics of network and other data communication lines.

1) Indicate methods used to achieve systems integration.
2) Indicate control, signal, and data communication paths and identify PLCs, networks, control interface devices, and media to be used.
3) Describe characteristics of network and other data communication lines.
4) Describe methods used to protect against power outages and transient voltages including types and ratings of isolation and surge suppression devices used in data, communication, signal, control, and ac and dc power circuits.

b. Raceway Riser Diagrams: Detail raceway runs required for intrusion detection and for systems integration. Include designation of devices connected by raceway, raceway type and size, and type and size of wire and cable fill for each raceway run.
c. UPS: Sizing calculations.
d. Site and Floor Plans: Indicate final outlet and device locations, routing of raceways, and cables inside and outside the building. Include room layout for master control-unit console, terminal cabinet, racks, and UPS.
e. Master Control-Unit Console Layout: Show required artwork and device identification.
f. Device Address List: Coordinate with final system programming.
g. System Wiring Diagrams: Include system diagrams unique to Project. Show connections for all devices, components, and auxiliary equipment. Include diagrams for equipment and for system with all terminals and interconnections identified.
h. Details of surge-protection devices and their installation.
i. Sensor detection patterns and adjustment ranges.

3. Equipment and System Operation Description: Include method of operation and supervision of each component and each type of circuit. Show sequence of operations for manually and automatically initiated system or equipment inputs. Description must cover this specific Project; manufacturer's standard descriptions for generic systems are unacceptable.
4. Samples for Initial Selection: For units with factory-applied color finishes.
5. Samples for Verification: For each type of exposed finish required.

E. Information Submittals
1. Qualification Data: For Installer **OR** intrusion detection systems integrator **OR** testing agency, **as directed**.
2. Field quality-control reports.
3. Warranty: Sample of special warranty.
4. Other Information Submittals:
a. Test Plan and Schedule: Test plan defining all tests required to ensure that system meets technical, operational, and performance specifications within 60 days of date of Contract award.
b. Examination reports documenting inspections of substrates, areas, and conditions.
c. Anchor inspection reports documenting inspections of built-in and cast-in anchors.

F. Closeout Submittals
1. Operation and Maintenance Data: For intrusion detection system to include in emergency, operation, and maintenance manuals," include the following:
a. Data for each type of product, including features and operating sequences, both automatic and manual.
b. Master control-unit hardware and software data.

G. Quality Assurance
1. Installer Qualifications:
a. An employer of workers, at least one of whom is a technician certified by the National Burglar & Fire Alarm Association **OR** possess the standards and experience for certification, **as directed**.
b. Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

2. Intrusion Detection Systems Integrator Qualifications: An experienced intrusion detection equipment supplier and Installer who has completed systems integration work for installations similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.
3. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the National Burglar & Fire Alarm Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to Owner's insurance underwriter.
   a. Testing Agency's Field Supervisor: Person currently certified as an advanced alarm technician by the National Burglar & Fire Alarm Association **OR** possess the standards and experience for certification, **as directed,** to supervise on-site testing specified in Part 3.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
5. Control Units, Devices, and Communications with Monitoring Station: Listed and labeled by a qualified testing agency for compliance with SIA CP-01.
6. FM Global Compliance: FMG-Approved and -labeled intrusion detection devices and equipment.
7. Comply with NFPA 70.

H. Project Conditions
1. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
   a. Altitude: Sea level to 4000 feet (1220 m).
   b. Master Control Unit: Rated for continuous operation in an ambient of 60 to 85 deg F (16 to 29 deg C) and a relative humidity of 20 to 80 percent, noncondensing.
   c. Interior, Controlled Environment: System components, except master station control unit, installed in air-conditioned **OR** temperature-controlled, **as directed,** interior environments shall be rated for continuous operation in ambients of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
   d. Interior, Uncontrolled Environment: System components installed in non-air-conditioned **OR** non-temperature-controlled, **as directed,** interior environments shall be rated for continuous operation in ambients of 0 to 122 deg F (minus 18 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
   e. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambients of minus 30 to plus 122 deg F (minus 34 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, condensing. Comply with UL 294 and UL 639 for outdoor-use equipment. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h) and snow cover up to 24 inches (610 mm) thick.
   f. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings shall be rated, listed, and installed according to NFPA 70.

I. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer and Installer agree to repair or replace components of intrusion detection devices and equipment that fail in materials or workmanship within specified warranty period.
2. Warranty Period: Two years from date of Final Completion.

1.2 PRODUCTS

A. Functional Description Of System
1. Description: Hard-wired **OR** Multiplexed, modular, microprocessor-based controls, intrusion sensors and detection devices, and communication links to perform monitoring, alarm, and control functions.

2. Supervision: System components shall be continuously monitored for normal, alarm, supervisory, and trouble conditions. Indicate deviations from normal conditions at any location in system. Indication includes identification of device or circuit in which deviation has occurred and whether deviation is an alarm or malfunction.
   a. Alarm Signal: Display at master station control unit and actuate audible and visual alarm devices.
   b. Trouble Condition Signal: Distinct from other signals, indicating that system is not fully functional. Trouble signal shall indicate system problems such as battery failure, open or shorted transmission line conductors, or controller failure.
   c. Supervisory Condition Signal: Distinct from other signals, indicating an abnormal condition as specified for the particular device or controller.
3. System Control: Master station control unit shall directly monitor intrusion detection units and connecting wiring.
   OR
   System Control: Master station control unit shall directly monitor intrusion detection devices, perimeter detection units **OR** controllers associated with perimeter detection units, **as directed,** and connecting wiring in a multiplexed distributed control system or as part of a network.
4. System shall automatically reboot program without error or loss of status or alarm data after any system disturbance.
5. Operator Commands:
   a. Help with System Operation: Display all commands available to operator. Help command, followed by a specific command, shall produce a short explanation of the purpose, use, and system reaction to that command.
   b. Acknowledge Alarm: To indicate that alarm message has been observed by operator.
   c. Place Protected Zone in Access: Disable all intrusion-alarm circuits of a specific protected zone. Tamper circuits may not be disabled by operator.
   d. Place Protected Zone in Secure: Activate all intrusion-alarm circuits of a protected zone.
   e. Protected Zone Test: Initiate operational test of a specific protected zone.
   f. System Test: Initiate system-wide operational test.
   g. Print Reports.
6. Timed Control at Master station control unit: Allow automatically timed "secure" and "access" functions of selected protected zones.
7. Automatic Control of Related Systems: Alarm or supervisory signals from certain intrusion detection devices control the following functions in related systems:
   a. Switch selected lights.
   b. Shift elevator control to a different mode.
   c. Open a signal path between certain intercommunication stations.
   d. Shift sound system to "listening mode" and open a signal path to certain system speakers.
   e. Switch signal to selected monitor from closed-circuit television camera in vicinity of sensor signaling an alarm.
8. Printed Record of Events: Print a record of alarm, supervisory, and trouble events on system printer. Sort and report by protected zone, device, and function. When master station control unit receives a signal, print a report of alarm, supervisory, or trouble condition. Report type of signal (alarm, supervisory, or trouble), protected zone description, date, and time of occurrence. Differentiate alarm signals from other indications. When system is reset, report reset event with the same information concerning device, location, date, and time. Commands shall initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.
9. Response Time: Two seconds between actuation of any alarm and its indication at master station control unit.
10. Circuit Supervision: Supervise all signal and data transmission lines, links with other systems, and sensors from master station control unit. Indicate circuit and detection device faults with both protected zone and trouble signals, sound a distinctive audible tone, and illuminate an LED. Maximum permissible elapsed time between occurrence of a trouble condition and indication at

master station control unit is 20 seconds. Initiate an alarm in response to opening, closing, shorting, or grounding of a signal or data transmission line.

11. Programmed Secure-Access Control: System shall be programmable to automatically change status of various combinations of protected zones between secure and access conditions at scheduled times. Status changes may be preset for repetitive, daily, and weekly; specially scheduled operations may be preset up to a year in advance. Manual secure-access control stations shall override programmed settings.
12. Manual Secure-Access Control: Coded entries at manual stations shall change status of associated protected zone between secure and access conditions.

B. System Component Requirements
1. Compatibility: Detection devices and their communication features, connecting wiring, and master station control unit shall be selected and configured with accessories for full compatibility with existing equipment:
2. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor entry connection to components.
   a. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits".
   b. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits" as recommended by manufacturer for type of line being protected.
3. Intrusion Detection Units: Listed and labeled by a qualified testing agency for compliance with UL 639.
4. Interference Protection: Components shall be unaffected by radiated RFI and electrical induction of 15 V/m over a frequency range of 10 to 10,000 MHz and conducted interference signals up to 0.25-V RMS injected into power supply lines at 10 to 10,000 MHz.
5. Tamper Protection: Tamper switches on detection devices, controllers, annunciators, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled and when entering conductors are cut or disconnected. Central-station control-unit alarm display shall identify tamper alarms and indicate locations.
6. Self-Testing Devices: Automatically test themselves periodically, but not less than once per hour, to verify normal device functioning and alarm initiation capability. Devices transmit test failure to master station control unit.
7. Antimasking Devices: Automatically check operation continuously or at intervals of a minute or less, and use signal-processing logic to detect blocking, masking, jamming, tampering, or other operational dysfunction. Devices transmit detection of operational dysfunction to master station control unit as an alarm signal.
8. Addressable Devices: Transmitter and receivers shall communicate unique device identification and status reports to master station control unit.
9. Remote-Controlled Devices: Individually and remotely adjustable for sensitivity and individually monitored at master station control unit for calibration, sensitivity, and alarm condition.

C. Enclosures
1. Interior Sensors: Enclosures that protect against dust, falling dirt, and dripping noncorrosive liquids.
2. Interior Electronics: NEMA 250, Type 12.
3. Exterior Electronics: NEMA 250, Type 4X fiberglass **OR** stainless steel, **as directed**.
4. Corrosion Resistant: NEMA 250, Type 4X PVC **OR** stainless steel, **as directed**.
5. Screw Covers: Where enclosures are accessible to inmates, secure with security fasteners of type appropriate for enclosure.

D. Secure And Access Devices

1. Keypad and Display Module: Arranged for entering and executing commands for system-status changes and for displaying system-status and command-related data.
2. Key-Operated Switch: Change protected zone between secure and access conditions.

E. Door And Window Switches
1. Description: Balanced-magnetic switch, complying with UL 634, installed on frame with integral overcurrent device to limit current to 80 percent of switch capacity. Bias magnet and minimum of two **OR** three, **as directed,** encapsulated reed switches shall resist compromise from introduction of foreign magnetic fields.
2. Flush-Mounted Switches: Unobtrusive and flush with surface of door and window frame.
3. Overhead Door Switch: Balanced-magnetic type, listed for outdoor locations, and having door-mounting magnet and floor-mounting switch unit.
4. Remote Test: Simulate movement of actuating magnet from master station control unit.

F. PIR Sensors
1. Listed and labeled by a qualified testing agency for compliance with SIA PIR-01.
2. Description: Sensors detect intrusion by monitoring infrared wavelengths emitted from a human body within their protected zone and by being insensitive to general thermal variations.
   a. Wall-Mounting Unit Maximum Detection Range: 125 percent of indicated distance for individual units and not less than 50 feet (15 m). Provide adjustable coverage pattern as indicated.
   b. Ceiling-Mounting Unit Spot-Detection Pattern: Full 360-degree conical.
   c. Ceiling-Mounting Unit Pattern Size: 84-inch (2135-mm) diameter at floor level for units mounted 96 inches (2440 mm) above floor; 18-foot (5.5-m) diameter at floor level for units mounted 25 feet (7.6 m) above floor.
3. Device Performance:
   a. Sensitivity: Adjustable pattern coverage to detect a change in temperature of 2 deg F (1deg C) or less, and standard-intruder movement within sensor's detection patterns at any speed between 0.3 to 7.5 fps (0.09 to 2.3 m/s) across 2 adjacent segments of detector's field of view.
   b. Test Indicator: LED test indicator that is not visible during normal operation. When visible, indicator shall light when sensor detects an intruder. Locate test enabling switch under sensor housing cover.
   c. Remote Test: When initiated by master station control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

G. Microwave Intrusion Detectors (Interior)
1. Device Performance: Microwave transmitter establishes an electromagnetic field in an adjustable detection pattern and detects intrusion by monitoring changes in that pattern.
   a. Sensitivity: Adjustable, able to detect standard-intruder movement within sensor's detection pattern at any speed between 0.3 to 7.5 fps (0.09 to 2.3 m/s). Sensor sensitivity adjustments shall be accessible only when sensor housing is removed, and sensors shall comply with 47 CFR 15.
   b. Activation Indicator: LED indicator shall not be visible during normal operation. Indicator shall light when sensor detects a standard intruder. Locate test-enabling switch under sensor housing cover.
   c. Remote Test: When initiated by master station control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

H. Acoustic-Type, Glass-Break Sensors
1. Listed and labeled by a qualified testing agency for compliance with SIA GB-01.
2. Device Performance: Detect unique, airborne acoustic energy spectrum caused by breaking glass.

a. Sensor Element: Microprocessor-based, digital device to detect breakage of plate, laminate, tempered, and wired glass while rejecting common causes of false alarms. Detection pattern shall be at least a 20-foot (6-m) range.
b. Hookup Cable: Factory installed, not less than 72 inches (1830 mm).
c. Activation Indicator: LED on sensor housing that lights when responding to vibrations, remaining on until manually reset at sensor controller or at master station control unit.
d. Controller: Integral with sensor housing or in a separate assembly, locally adjustable by control under housing cover.
e. Glass-Break Simulator: A device to induce frequencies into protected glass pane that simulate breaking glass without causing damage to glass.

I. Piezoelectric-Type, Glass-Break Sensors
1. Listed and labeled by a qualified testing agency for compliance with SIA GB-01.
2. Device Performance: Detect unique, high-frequency vibrations caused by breaking glass.
a. Sensor Element: Piezoelectric crystals in a housing designed to mount directly to glass surface with adhesive provided by element manufacturer. Circular detection pattern, with at least a 60-inch (1525-mm) radius on a continuous glass pane. Sensor element shall not be larger than 4 sq. in. (25.80 sq. cm).
b. Hookup Cable: Factory installed, not less than 72 inches (1830 mm).
c. Activation Indicator: LED on sensor housing that lights when responding to vibrations, remaining on until manually reset at sensor controller or at master station control unit.
d. Controller: Integral with sensor housing or in a separate assembly, locally adjustable by control under housing cover.
e. Glass-Break Simulator: A device to induce frequencies into protected glass pane that simulate breaking glass without causing damage to glass.

J. Vibration Sensors
1. Listed and labeled by a qualified testing agency for compliance with SIA GB-01.
2. Description: A sensor controller and piezoelectric crystal sensor elements that are designed to be rigidly mounted to structure being protected.
3. Device Performance: Detects high-frequency vibrations generated by use of such tools as oxyacetylene torches, oxygen lances, high-speed drills and saws, and explosives that penetrate a structure while not responding to any other mechanical vibration.
a. Circular detection pattern, with at least a 72-inch (1830-mm) radius on protected structure.
b. Hookup Cable: Factory installed, not less than 72 inches (1830 mm).
c. Controller: Integral with sensor housing or in a separate assembly, locally adjustable by control under housing cover.
d. Glass-Break Simulator: A device to induce frequencies to protected glass pane that simulate breaking glass without causing damage to glass.

K. Photoelectric Sensors
1. Device Performance: Detect an interruption of a pulsed, infrared, light beam that links transmitter and receiver.
a. Sensitivity: Detect standard-intruder movement within sensor's detection patterns at any speed of less than 7.5 fps (2.3 m/s) though the beam. Allow installation of multiple sensors within same protected zone that will not interfere with each other.
b. Activation Indicator: LED indicator shall not be visible during normal operation. Indicator shall light when sensor detects a standard intruder. Locate test enabling switch under sensor housing cover.
c. Remote Test: When initiated by master station control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

L. Microwave-PIR Dual-Technology Motion Sensors

1. Description: Single unit combining a sensor that detects changes in microwave signals and a PIR sensor that detects changes in ambient level of infrared emissions caused by standard-intruder movement within detection pattern.
2. Device Performance: An alarm is transmitted when either sensor detects a standard intruder within a period of three to eight seconds from when the other sensor detects a standard intruder.
   a. Minimum Detection Pattern: A room 20 by 30 feet (6 by 9 m).
   b. PIR Sensor Sensitivity: Adjustable pattern coverage to detect a change in temperature of 2 deg F (1 deg C) or less, and standard-intruder movement within sensor's detection patterns at any speed between 0.3 to 7.5 fps (0.09 to 2.3 m/s) across 2 adjacent segments of detector's field of view.
   c. Microwave Sensor Sensitivity: Adjustable, able to detect standard-intruder movement within sensor's detection pattern at any speed between 0.3 to 7.5 fps (0.09 to 2.3 m/s). Sensor sensitivity adjustments shall be accessible only when sensor housing is removed, and sensors shall comply with 47 CFR 15.
   d. Activation Indicator: LED indicator shall not be visible during normal operation. Indicator shall light when sensor detects a standard intruder. Locate test enabling switch under sensor housing cover.
   e. Remote Test: When initiated by master station control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

M. Duress-Alarm Switches
1. Description: A switch with a shroud over the activating lever that allows an individual to covertly send a duress signal to master station control unit, with no visible or audible indication when activated. Switch shall lock in activated position until reset with a key.
   a. Minimum Switch Rating: 50,000 operations.
   b. Foot Rail: Foot activated, floor mounting.
   c. Push Button: Finger activated, suitable for mounting on horizontal or vertical surface.

N. Video Motion Sensor (Interior)
1. Device Performance: Detect changes in video signal within a user-defined protected zone. Video inputs shall be composite video as defined in EIA 170. Provide an alarm output for each video input.
   a. Detect movement within protected zone of standard intruders wearing clothing with a reflectivity that differs from that of background scene by a factor of 2. Reject all other changes in video signal.
   b. Modular design that allows for expansion or modification of number of inputs.
   c. Controls:
      1) Number of detection zones.
      2) Size of detection zones.
      3) Sensitivity of detection of each protected zone.
   d. Mounting: Standard 19-inch (480-mm) rack as described in EIA 310.

O. Master Control Units
1. Description: Supervise sensors and detection subsystems and their connecting communication links, status control (secure or access) of sensors and detector subsystems, activation of alarms and supervisory and trouble signals, and other indicated functions.
   a. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
   b. Include a real-time clock for time annotation of events on the event recorder and printer.
   c. Addressable initiation devices that communicate device identity and status.
   d. Control circuits for operation of mechanical equipment in response to an alarm.
2. Construction: Freestanding equipment rack **OR** Desk-mounted console, **as directed** modular, with separate and independent alarm and supervisory system modules. Alarm-initiating protected

zone boards shall be plug-in cards. Arrangements that require removal of field wiring for module replacement are unacceptable.

3. Comply with UL 609 **OR** UL 1023 **OR** UL 1076, **as directed**.
4. Console Controls and Displays: Arranged for interface between human operator at master control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
   a. Annunciator and Display: LCD, one **OR** two **OR** three line(s), as directed of 40 **OR** 80 characters, as directed, minimum.
   b. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
   c. Control-Unit Network: Automatic communication of alarm, status changes, commands, and other communications required for system operation. Communication shall return to normal after partial or total network interruption such as power loss or transient event. Total or partial signaling network failures shall identify the failure and record the failure at the annunciator display and at the system printer.
   d. Field Device Network: Communicate between the control unit and field devices of the system. Communications shall consist of alarm, network status, and status and control of field-mounted processors. Each field-mounted device shall be interrogated during each interrogation cycle.
   e. Operator Controls: Manual switches and push-to-test buttons that do not require a key to operate. Prevent resetting of alarm, supervisory, or trouble signals while alarm or trouble condition persists. Include the following:
      1) Acknowledge alarm.
      2) Silence alarm.
      3) System reset.
      4) LED test.
   f. Timing Unit: Solid state, programmable, 365 days.
   g. Confirmation: Relays, contactors, and other control devices shall have auxiliary contacts that provide confirmation signals to system for their on or off status. Software shall interpret such signals, display equipment status, and initiate failure signals.
   h. Alarm Indication: Audible signal sounds and a plain-language identification **OR** LED **OR** LCD OR cathode ray-tube display at master control unit identifying the protected zone **OR** addressable detector**, as directed** originating the alarm. Annunciator panel displays a common alarm light and sounds an audible tone.
   i. Alarm activation sounds a bell or siren or strobe **OR** bell or siren and strobe**, as directed**.
5. Protected Zones: Quantity of alarm and supervisory zones as indicated, with capacity for expanding number of protected zones by a minimum of 25 percent.
6. Power Supply Circuits: Master station control units shall provide power for remote power-consuming detection devices. Circuit capacity shall be adequate for at least a 25 percent increase in load.
7. UPS: Comply with Division 26 Section "Static Uninterruptible Power Supply". UPS shall be sized to provide a minimum of six hours of central-station control-unit operation.
8. Cabinet: Lockable, steel enclosure arranged so operations required for testing, normal operation, and maintenance are performed from front of enclosure. If more than a single cabinet is required to form a complete control unit, provide exactly matching modular enclosures. Accommodate all components and allow ample gutter space for field wiring. Identify each enclosure by an engraved, laminated, phenolic-resin nameplate. Lettering on enclosure nameplate shall not be less than 1 inch (25 mm) high. Identify, with permanent labels, individual components and modules within cabinets.
9. Transmission to Monitoring Station: A communications device to automatically transmit alarm, supervisory, and trouble signals to the monitoring station, operating over a standard voice grade telephone leased line. Comply with UL 1635.
10. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print

system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

P. Audible And Visual Alarm Devices
1. Bell: 10 inches (254 mm) in diameter, rated to produce a minimum sound output of 84 dB at 10 feet (3 m) from master control unit.
   a. Enclosure: Weather-resistant steel box equipped with tamper switches on cover and on back of box.
2. Klaxon Weatherproof Motor-Driven Hooter: UL listed, rated to produce a minimum sound output of 120 dB at 3 feet (1 m), plus or minus 3 dB, at a frequency of 470 Hz. Rated for intermittent use: two minutes on and five minutes off.
   a. Designed for use in industrial areas and in high-noise, severe-weather marine environments.
3. Siren: 30-W speaker with siren driver, rated to produce a minimum sound output of 103 dB at 10 feet (3 m) from master control unit.
   a. Enclosure: Weather-resistant steel box with tamper switches on cover and on back of box.
4. Strobe: Xenon light complying with UL 1638, with a clear polycarbonate lens.
   a. Light Output: 115 cd, minimum.
   b. Flash Rate: 60 per minute.

Q. Security Fasteners
1. Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator. Drive system type, head style, material, and protective coating as required for assembly, installation, and strength.
2. Drive System Types: Pinned Torx-Plus **OR** pinned Torx **OR** pinned hex (Allen)**, as directed**.
3. Socket Flat Countersunk Head Fasteners:
   a. Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
   b. Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
4. Socket Button Head Fasteners:
   a. Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
   b. Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
5. Socket Head Cap Fasteners:
   a. Heat-treated alloy steel, ASTM A 574 (ASTM A 574M).
   b. Stainless steel, ASTM F 837 (ASTM F 837M), Group 1 CW.
6. Protective Coatings for Heat-Treated Alloy Steel:
   a. Zinc chromate, ASTM F 1135, Grade 3 or Grade 4, for exterior applications and interior applications where indicated.
   b. Zinc phosphate with oil, ASTM F 1137, Grade I, or black oxide unless otherwise indicated.

1.3 EXECUTION

A. Examination
1. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of intrusion detection.
2. Examine roughing-in for embedded and built-in anchors to verify actual locations of intrusion detection connections before intrusion detection installation.
3. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of intrusion detection.
4. Inspect built-in and cast-in anchor installations, before installing intrusion detection, to verify that anchor installations comply with requirements. Prepare inspection reports.
   a. Remove and replace anchors where inspections indicate that they do not comply with requirements. Reinspect after repairs or replacements are made.

b. Perform additional inspections to determine compliance of replaced or additional anchor installations. Prepare inspection reports.

5. For material whose orientation is critical for its performance as a ballistic barrier, verify installation orientation.
6. Proceed with installation only after unsatisfactory conditions have been corrected.

B. System Integration
1. Electronic door hardware.
2. Elevators.
3. Network lighting controls.
4. Intercommunications and program systems.
5. Public address and mass notification systems.
6. Access control.
7. Fire-alarm system.
8. Perimeter security system.
9. Video surveillance.

C. System Installation
1. Comply with UL 681 and NFPA 731.
2. Equipment Mounting: Install master control unit on finished floor with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
   a. Comply with requirements for seismic-restraint devices specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
3. Install wall-mounted equipment, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
   a. Comply with requirements for seismic-restraint devices specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
4. Connecting to Existing Equipment: Verify that existing perimeter security system is operational before making changes or connections.
   a. Connect new equipment to existing control panel in existing part of the building.
   b. Connect new equipment to existing monitoring equipment at the Supervising Station.
   c. Expand, modify, and supplement existing control **OR** monitoring equipment**, as directed** as necessary to extend existing control **OR** monitoring functions**, as directed** to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.
5. Security Fasteners: Where accessible to inmates, install intrusion detection components using security fasteners with head style appropriate for fabrication requirements, strength, and finish of adjacent materials except that a maximum of two different sets of tools shall be required to operate security fasteners for Project. Provide stainless-steel security fasteners in stainless-steel materials.

D. Wiring Installation
1. Wiring Method: Install wiring in metal raceways according to Division 26 Section "Raceway And Boxes For Electrical Systems". Conceal raceway except in unfinished spaces and as indicated. Minimum conduit size shall be 1/2 inch (13 mm). Control and data transmission wiring shall not share conduit with other building wiring systems.
2. Wiring Method: Install wiring in raceways except in accessible indoor ceiling spaces and in interior hollow gypsum board partitions where cable may be used. Conceal raceways and wiring except in unfinished spaces and as indicated. Minimum conduit size shall be 1/2 inch (13 mm). Control and data transmission wiring shall not share conduit with other building wiring systems.
3. Wiring Method: Cable, concealed in accessible ceilings, walls, and floors when possible.
4. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks. Mark each terminal according

to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

5. Wires and Cables:
   a. Conductors: Size as recommended in writing by system manufacturer, unless otherwise indicated.
   b. 120-V Power Wiring: Install according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables", unless otherwise indicated.
   c. Control and Signal Transmission Conductors: Install unshielded, twisted-pair cable, unless otherwise indicated or if manufacturer recommends shielded cable, according to Division 28 Section "Conductors And Cables For Electronic Safety And Security".
   d. Data and Television Signal Transmission Cables: Install according to Division 28 Section "Conductors And Cables For Electronic Safety And Security".
6. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
7. Install power supplies and other auxiliary components for detection devices at controllers, unless otherwise indicated or required by manufacturer. Do not install such items near devices they serve.
8. Identify components with engraved, laminated-plastic or metal nameplate for master station control unit and each terminal cabinet, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification For Electrical Systems".

E. Identification
1. Identify system components, wiring, cabling, and terminals. Comply with identification requirements as specified in Division 26 Section "Identification For Electrical Systems".
2. Install instructions frame in a location visible from master control unit.

F. Grounding
1. Ground the master control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to master control unit.
2. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
3. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding. Provide 5-ohm ground. Measure, record, and report ground resistance.
4. Install grounding electrodes of type, size, location, and quantity indicated. Comply with installation requirements in Division 26 Section "Grounding And Bonding For Electrical Systems".

G. Field Quality Control
1. Pretesting: After installation, align, adjust, and balance system and perform complete pretesting to determine compliance of system with requirements in the Contract Documents. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
   a. Report of Pretesting: After pretesting is complete, provide a letter certifying that installation is complete and fully operable; include names and titles of witnesses to preliminary tests.
2. Testing Agency: Engage a qualified testing and inspecting agency to perform tests and inspections.
3. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect test, and adjust components, assemblies, and equipment installations connections.
4. Perform tests and inspections.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
5. Test and Inspections: Comply with provisions in NFPA 731, Ch.9, “Testing and Inspections.”

a. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
b. Test Methods: Intrusion detection systems and other systems and equipment that are associated with detection and accessory equipment shall be tested according to Table "Test Methods" and Table "Test Methods of Initiating Devices."

6. Documentation: Comply with provisions in NFPA 731, Ch. 4, "Documentation."
7. Tag all equipment, stations, and other components for which tests have been satisfactorily completed.
8.

H. Adjusting
1. Occupancy Adjustments: When requested within 12 months of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose. Visits for this purpose shall be in addition to any required by warranty.

I. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain intrusion detection system. Comply with documentation provisions in NFPA 731, Ch.4, “Documentation and User Training."

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SECTION 28 16 11 00b - SECURITY ACCESS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for security access. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Security access central-control station.
b. One or more security access networked workstations.
c. Security access operating system and application software.
d. Security access controllers connected to high-speed electronic-data transmission network.

C. Definitions
1. CCTV: Closed-circuit television.
2. CPU: Central processing unit.
3. Credential: Data assigned to an entity and used to identify that entity.
4. dpi: Dots per inch.
5. DTS: Digital Termination Service. A microwave-based, line-of-sight communication provided directly to the end user.
6. GFI: Ground fault interrupter.
7. Identifier: A credential card; keypad personal identification number; or code, biometric characteristic, or other unique identification entered as data into the entry-control database for the purpose of identifying an individual. Where this term is presented with an initial capital letter, this definition applies.
8. I/O: Input/Output.
9. LAN: Local area network.
10. Location: A Location on the network having a PC-to-controller communications link, with additional controllers at the Location connected to the PC-to-controller link with a TIA 485-A communications loop. Where this term is presented with an initial capital letter, this definition applies.
11. PC: Personal computer. Applies to the central station, workstations, and file servers.
12. PCI Bus: Peripheral Component Interconnect. A peripheral bus providing a high-speed data path between the CPU and the peripheral devices such as a monitor, disk drive, or network.
13. PDF: Portable Document Format. The file format used by the Acrobat document-exchange-system software from Adobe.
14. RAS: Remote access services.
15. RF: Radio frequency.
16. ROM: Read-only memory. ROM data are maintained through losses of power.
17. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.
18. TWAIN: Technology without an Interesting Name. A programming interface that lets a graphics application, such as an image editing program or desktop publishing program, activate a scanner, frame grabber, or other image-capturing device.
19. UPS: Uninterruptible power supply.
20. USB: Universal serial bus.
21. WAN: Wide area network.
22. WAV: The digital audio format used in Microsoft Windows.
23. WMP: Windows media player.
24. Wiegand: Patented magnetic principle that uses specially treated wires embedded in the credential card.

25. Windows: Operating system by Microsoft Corporation.
26. Workstation: A PC with software that is configured for specific, limited security-system functions.
27. WYSIWYG: What You See Is What You Get. Text and graphics appear on the screen the same as they will in print.

D. Submittals
1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Reference each product to a location on Drawings. Test and evaluation data presented in Product Data shall comply with SIA BIO-01.
2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   a. Diagrams for cable management system.
   b. System labeling schedules, including electronic copy of labeling schedules that are part of the cable and asset identification system of the software specified in Parts 1.2 and 1.3.
   c. Wiring Diagrams. For power, signal, and control wiring. Show typical wiring schematics including the following:
      1) Workstation outlets, jacks, and jack assemblies.
      2) Patch cords.
      3) Patch panels.
   d. Cable Administration Drawings: As specified in Part 1.3 "Identification" Article.
   e. Battery and charger calculations for Central Station, workstations, and Controllers.
3. Samples: For workstation outlets, jacks, jack assemblies, and faceplates. For each exposed product and for each color and texture specified.
4. Other Action Submittals:
   a. Project planning documents as specified in Part 1.3.
5. Field quality-control test reports.
6. Operation and Maintenance Data: For security system to include in emergency, operation, and maintenance manuals. Include the following:
   a. Microsoft Windows software documentation.
   b. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Software shall include system restore, emergency boot diskettes, and drivers for all installed hardware. Provide separately for each PC.
   c. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.
   d. System installation and setup guides, with data forms to plan and record options and setup decisions.

E. Quality Assurance
1. Installer Qualifications: An employer of workers trained and approved by manufacturer.
   a. Cable installer must have on staff a registered communication distribution designer certified by Building Industry Consulting Service International.
2. Source Limitations: Obtain Central Station, workstations, Controllers, Identifier readers, and all software through one source from a single manufacturer.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 by a qualified testing agency, and marked for intended use.
4. Comply with NFPA 70, "National Electrical Code."
5. Comply with SIA DC-01 and SIA DC-03 and SIA DC-07, **as directed**.

F. Delivery, Storage, And Handling
1. Central Station, Workstations, and Controllers:
   a. Store in temperature- and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature between 50 and 85 deg F (10 and 30 deg C), and not more than 80 percent relative humidity, noncondensing.
   b. Open each container; verify contents against packing list, and file copy of packing list, complete with container identification for inclusion in operation and maintenance data.

c. Mark packing list with designations that have been assigned to materials and equipment for recording in the system labeling schedules that are generated by cable and asset management system specified in Part 2.
d. Save original manufacturer's containers and packing materials and deliver as directed under provisions covering extra materials.

G. Project Conditions
1. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
a. Control Station: Rated for continuous operation in ambient conditions of 60 to 85 deg F (16 to 30 deg C) and a relative humidity of 20 to 80 percent, noncondensing.
b. Indoor, Controlled Environment: NEMA 250, Type 1 enclosure. System components, except central-station control unit, installed in air-conditioned **OR** temperature-controlled, **as directed**, indoor environments shall be rated for continuous operation in ambient conditions of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
c. Indoor, Uncontrolled Environment: NEMA 250, Type 3R **OR** 4 **OR** 12 **OR** 12K, **as directed**, enclosures. System components installed in non-air-conditioned **OR** non-temperature-controlled, **as directed**, interior environments shall be rated for continuous operation in ambient conditions of 0 to 122 deg F (minus 18 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
d. Outdoor Environment: NEMA 250, Type 3 **OR** 3R **OR** 3S **OR** 4 **OR** 4X, **as directed**, enclosures. System components installed in locations exposed to weather shall be rated for continuous operation in ambient conditions of minus 30 to plus 122 deg F (minus 34 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation where exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h) and snow cover up to 24 inches (610 mm) thick.
e. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.
f. Corrosive Environment: For system components subjected to corrosive fumes, vapors, and wind-driven salt spray in coastal zones, provide NEMA 250, Type 4X **OR** 6P, **as directed**, enclosures.

1.2 PRODUCTS

A. Description
1. Security Access System: PC-based central station, one or more networked PC-based workstations, and field-installed controllers, connected by a high-speed electronic-data transmission network.
2. System Software: Based on 32-bit, central-station, workstation operating system, server operating system, and application software. Software shall have the following capabilities:
a. Multiuser and multitasking to allow for independent activities and monitoring to occur simultaneously at different workstations.
b. Graphical user interface to show pull-down menus and a menu-tree format that complies with interface guidelines of Microsoft Windows.
c. System license for the entire system including capability for future additions that are within the indicated system size limits specified in this Section.
d. Open-architecture system that allows importing and exporting of data and interfacing with other systems that are compatible with Microsoft Windows.
e. Password-protected operator login and access.
f. Open-database-connectivity compliant.
3. Network connecting the central station and workstations shall be a LAN **OR** WAN, **as directed,** using Microsoft Windows-based TCP/IP with a capacity of connecting up to 99 workstations.

System shall be portable across multiple communication platforms without changing system software.

4. Network(s) connecting PCs and controllers shall consist of one or more of the following:
   a. Local area, IEEE 802.3 Fast Ethernet Gigabit-Ethernet **OR** 100 BASE-TX, **as directed**, star topology network based on TCP/IP.
   b. Direct-connected, RS-232 cable from the COM port of the central station to the first controller, then RS-485 cable to interconnect the remaining controllers at that Location.
   c. Dial-up and cable modem connection using a standard cable or dial-up telephone line.

B. Operation
1. Security access system shall use a single database for access-control and credential-creation functions.
2. Distributed Processing: A fully distributed processing system.
   a. Access-control information, including time, date, valid codes, access levels, and similar data, shall be downloaded to controllers so each controller can make access-control decisions.
   b. Intermediate controllers for access control are prohibited.
   c. In the event that communications with the central controller are lost, controllers shall automatically buffer event transactions until communications are restored, at which time buffered events shall be uploaded to the central station.
3. Number of Locations:
   a. Support at least 32,000 separate Locations using a single PC with combinations of direct-connect, dial-up, or TCP/IP LAN connections to each Location.
   b. Each Location shall have its own database and history in the central station.
   c. Locations may be combined to share a common database.
4. Data Capacity:
   a. 130 different card-reader formats.
   b. 999 comments.
   c. 48 graphic file types for importing maps.
5. Location Capacity:
   a. 128 reader-controlled doors.
   b. 50,000 total-access credentials.
   c. 2048 supervised alarm inputs.
   d. 2048 programmable outputs.
   e. 32,000 custom action messages per Location to instruct operator on action required when alarm is received.
6. System Network Requirements:
   a. System components shall be interconnected and shall provide automatic communication of status changes, commands, field-initiated interrupts, and other communications required for proper system operation.
   b. Communication shall not require operator initiation or response and shall return to normal after partial- or total-network interruption such as power loss or transient upset.
   c. System shall automatically annunciate communication failures to the operator and shall identify the communications link that has experienced a partial or total failure.
   d. Communications controller may be used as an interface between the central-station display systems and the field device network. Communications controller shall provide functions required to attain the specified network communications performance.
7. Central station shall provide operator interface, interaction, display, control, and dynamic and real-time monitoring. Central station shall control system networks to interconnect all system components, including workstations and field-installed controllers.
8. Field equipment shall include controllers, sensors, and controls.
   a. Controllers shall serve as an interface between the central station and sensors and controls.
   b. Data exchange between the central station and the controllers shall include down-line transmission of commands, software, and databases to controllers.

c. The up-line data exchange from the controller to the central station shall include status data such as intrusion alarms, status reports, and entry-control records.
d. Controllers are classified as alarm-annunciation or entry-control type.

9. System Response to Alarms:
   a. Field device network shall provide a system end-to-end response time of one second(s) or less for every device connected to the system.
   b. Alarms shall be annunciated at the central station within one second of the alarm occurring at a controller or at a device controlled by a local controller, and within 100 ms if the alarm occurs at the central station.
   c. Alarm and status changes shall be displayed within 100 ms after receipt of data by the central station.
   d. All graphics shall be displayed, including graphics-generated map displays, on the console monitor within five seconds of alarm receipt at the security console.
   e. This response time shall be maintained during system heavy load.
10. False-Alarm Reduction: The design of the central station and controllers shall contain features to reduce false alarms. Equipment and software shall comply with SIA CP-01.
11. Error Detection:
   a. Use a cyclic code method to detect single- and double-bit errors, burst errors of eight bits or fewer, and at least 99 percent of all other multibit and burst errors between controllers and the central station.
   b. Interactive or product error-detection codes alone will not be acceptable.
   c. A message shall be in error if one bit is received incorrectly.
   d. Retransmit messages with detected errors.
   e. Allow for an operator-assigned two-digit decimal number to each communications link representing the number of retransmission attempts.
   f. Central station shall print a communication failure alarm message when the number of consecutive retransmission attempts equals the assigned quantity.
   g. Monitor the frequency of data transmission failure for display and logging.
12. Data Line Supervision: System shall initiate an alarm in response to opening, closing, shorting, or grounding of data transmission lines.
13. Door Hardware Interface:
   a. Comply with requirements in Division 8 Sections for door hardware required to be monitored or controlled by the security access system.
   b. Electrical characteristics of controllers shall match the signal and power requirements of door hardware.

C. Application Software
1. System Software: Based on 32-bit, Microsoft Windows central-station and workstation operating system and application software.
   a. Multiuser multitasking shall allow independent activities and monitoring to occur simultaneously at different workstations.
   b. Graphical user interface shall show pull-down menus and a menu-tree format.
   c. Capability for future additions within the indicated system size limits.
   d. Open architecture that allows importing and exporting of data and interfacing with other systems that are compatible with operating system.
   e. Password-protected operator login and access.
2. Peer Computer Control Software: Detect a failure of a central computer and cause the other central computer to assume control of all system functions without interruption of operation. Both central computers shall have drivers to support this mode of operation.
3. Application Software: Interface between the alarm annunciation and entry-control controllers to monitor sensors and DTS links, operate displays, report alarms, generate reports, and help train system operators.
   a. Reside at the central station, workstations, and controllers as required to perform specified functions.
   b. Operate and manage peripheral devices.

c. Manage files for disk I/O, including creating, deleting, and copying files; and automatically maintain a directory of all files, including size and location of each sequential and random-ordered record.
d. Import custom icons into graphics to represent alarms and I/O devices.
e. Globally link I/O so that any I/O can link to any other I/O within the same Location without requiring interaction with the host PC. This operation shall be at the controller.
f. Globally code I/O links so that any access-granted event can link to any I/O with the same Location without requiring interaction with the host PC. This operation shall be at the controller.
g. Messages from PC to controllers and controllers to controllers shall be on a polled network that utilizes check summing and acknowledgment of each message. Communication shall be automatically verified, buffered, and retransmitted if message is not acknowledged.
h. Selectable poll frequency and message time-out settings shall handle bandwidth and latency issues for TCP/IP, RF, and other PC-to-controller communications methods by changing the polling frequency and the amount of time the system waits for a response.
i. Automatic and encrypted backups for database and history backups shall be automatically stored at the central-control PC **OR** a selected workstation, **as directed**, and encrypted with a nine-character alphanumeric password that must be used to restore or read data contained in backup.
j. Operator audit trail for recording and reporting all changes made to database and system software.
k. Support network protocol and topology, TCP/IP, Novel Netware, Digital Pathworks, Banyan Vines, LAN/WAN, and RAS.

4. Workstation Software:
   a. Password levels shall be individually customized at each workstation to allow or disallow operator access to program functions for each Location.
   b. Workstation event filtering shall allow user to define events and alarms that will be displayed at each workstation. If an alarm is unacknowledged (not handled by another workstation) for a preset amount of time, the alarm will automatically appear on the filtered workstation.
5. Controller Software:
   a. Controllers shall operate as autonomous, intelligent processing units.
      1) Controllers shall make decisions about access control, alarm monitoring, linking functions, and door-locking schedules for their operation, independent of other system components.
      2) Controllers shall be part of a fully distributed processing-control network.
      3) The portion of the database associated with a controller, and consisting of parameters, constraints, and the latest value or status of points connected to that controller, shall be maintained in the controller.
   b. The following functions shall be fully implemented and operational within each controller:
      1) Monitoring inputs.
      2) Controlling outputs.
      3) Automatically reporting alarms to the central station.
      4) Reporting of sensor and output status to the central station on request.
      5) Maintaining real time, automatically updated by the central station at least once a day.
      6) Communicating with the central station.
      7) Executing controller resident programs.
      8) Diagnosing.
      9) Downloading and uploading data to and from the central station.
   c. Controller Operations at a Location:
      1) Up to 64 controllers connected to TIA 485-A communications loop. Globally operating I/O linking and anti-passback functions between controllers within the same Location without central-station or workstation intervention. Linking and anti-

passback shall remain fully functional within the same Location even when the central station or workstations are off-line.

2) In the event of communication failure between the central station and a Location, there shall be no degradation in operations at the controllers at that Location. Controllers at each Location shall be connected to a memory buffer with a capacity to store up to 10,000 events; there shall be no loss of transactions in system history files until the buffer overflows.

3) Buffered events shall be handled in a first-in-first-out mode of operation.

d. Individual Controller Operation:

1) Controllers shall transmit alarms, status changes, and other data to the central station when communications circuits are operable. If communications are not available, controllers shall function in a stand-alone mode; operational data, including the status and alarm data normally transmitted to the central station, shall be stored for later transmission to the central station. Storage capacity for the latest 1024 events shall be provided at each controller.

2) Card-reader ports of a controller shall be custom configurable for at least 120 different card-reader or keypad formats. Multiple reader or keypad formats may be used simultaneously at different controllers or within the same controller.

3) Controllers shall provide a response to card readers or keypad entries in less than 0.25 seconds, regardless of system size.

4) Controllers that are reset, or powered up from a nonpowered state, shall automatically request a parameter download and reboot to their proper working state. This shall happen without any operator intervention.

5) Initial Startup: When controllers are brought on-line, database parameters shall be automatically downloaded to them. After initial download is completed, only database changes shall be downloaded to each controller.

6) On failure for any reason, controllers shall perform an orderly shutdown and force controller outputs to a predetermined failure-mode state, consistent with the failure modes shown and the associated control device.

7) After power is restored, following a power failure, startup software shall initiate self-test diagnostic routines, after which controllers shall resume normal operation.

8) After controller failure, if the database and application software are no longer resident, controllers shall not restart but shall remain in the failure mode until repaired. If database and application programs are resident, controllers shall immediately resume operation. If not, software shall be restored automatically from the central station.

e. Communications Monitoring:

1) System shall monitor and report status of TIA 485-A communications loop of each Location.

2) Communication status window shall display which controllers are currently communicating, a total count of missed polls since midnight, and which controller last missed a poll.

3) Communication status window shall show the type of CPU, the type of I/O board, and the amount of RAM for each controller.

f. Operating systems shall include a real-time clock function that maintains seconds, minutes, hours, day, date, and month. The real-time clock shall be automatically synchronized with the central station at least once a day to plus or minus 10 seconds. The time synchronization shall be automatic, without operator action and without requiring system shutdown.

6. PC-to-Controller Communications:

a. Central-station or workstation communications shall use the following:

1) Direct connection using serial ports of the PC.

2) TCP/IP LAN interface cards.

3) Dial-up or cable modems for connections to Locations.

b. Each serial port used for communications shall be individually configurable for "direct communications," "modem communications incoming and outgoing," or "modem

communications incoming only," or as an ASCII output port. Serial ports shall have adjustable data transmission rates and shall be selectable under program control.

c. Use multiport communications board if more than two serial ports are needed.
   1) Use a 4-, 8-, or 16-serial port configuration that is expandable to 32- or 64-serial ports.
   2) Connect the first board to an internal PCI bus adapter card.

d. Direct serial, TCP/IP, and dial-up, cable, or satellite communications shall be alike in the monitoring or control of the system except for the connection that must first be made to a dial-up or voice-over IP Location.

e. TCP/IP network interface card (NIV) shall have an option to set the poll-frequency and message-response time-out settings.

f. PC-to-controller and controller-to-controller communications (direct, dial-up, or TCP/IP) shall use a polled-communication protocol that checks sum and acknowledges each message. All communications in this subparagraph shall be verified and buffered, and retransmitted if not acknowledged.

7. Direct Serial or TCP/IP PC-to-Controller Communications:
   a. Communication software on the PC shall supervise the PC-to-controller communications link.
   b. Loss of communications to any controller shall result in an alarm at all PCs running the communication software.
   c. When communications are restored, all buffered events shall automatically upload to the PC, and any database changes shall be automatically sent to the controller.
8. Dial-up Modem or Cable Modem PC-to-Controller Communications:
   a. Communication software on the PC shall supervise the PC-to-controller communications link during dial-up modem connect times.
   b. Communication software shall be programmable to routinely poll each of the remote dial-up or cable modem Locations, collecting event logs and verifying phone lines at operator-selectable time intervals for each Location.
   c. System shall be programmable for dialing and connecting to all dial-up or cable modem Locations and for retrieving the accrued history transactions on an automatic basis as often as once every 10 minutes and up to once every 9999 minutes.
   d. Failure to communicate to a dial-up Location three times in a row shall result in an alarm at the PC.
   e. Time offset capabilities shall be present so that Locations in a different geographical time zone than the host PC will be set to, and maintained at, the proper local time. This feature shall allow for geographical time zones that are ahead of or behind the host PC.
   f. The controller connected to a dial-up or cable modem shall automatically buffer all normal transactions until its buffer reaches 80 percent of capacity. When the transaction buffer reaches 80 percent, the controller shall automatically initiate a call to the central station and upload all transactions.
   g. Alarms shall be reported immediately.
   h. Dial-up or cable modems shall be provided by manufacturer of the system. Modems used at the controller shall be powered by the controller. Power to the modem shall include battery backup if the controller is so equipped.
9. Controller-to-Controller Communications:
   a. TIA 485-A, four-wire, point-to-point, regenerative (repeater) communications network methodology.
   b. TIA 485-A communications signal shall be regenerated at each controller.
10. Database Downloads:
   a. All data transmissions from PCs to a Location, and between controllers at a Location, shall include a complete database checksum to check the integrity of the transmission. If the data checksum does not match, a full data download shall be automatically retransmitted.
   b. If a controller is reset for any reason, it shall automatically request and receive a database download from the PC. The download shall restore data stored at the controller to their normal working state and shall take place with no operator intervention.

c. Software shall provide for setting downloads via dial-up connection to once per 24-hour period, with time selected by the operator.
d. Software shall provide for setting delays of database downloads for dial-up connections. Delays change the download from immediately to a delay ranging from one to 999 minutes.

11. Operator Interface:
a. Inputs in system shall have two icon representations, one for the normal state and one for the abnormal state.
b. When viewing and controlling inputs, displayed icons shall automatically change to the proper icon to display the current system state in real time. Icons shall also display the input's state, whether armed or bypassed, and if the input is in the armed or bypassed state due to a time zone or a manual command.
c. Outputs in system shall have two icon representations, one for the secure (locked) state and one for the open (unlocked) state.
d. Icons displaying status of the I/O points shall be constantly updated to show their current real-time condition without prompting by the operator.
e. The operator shall be able to scroll the list of I/Os and press the appropriate toolbar button, or right click, to command the system to perform the desired function.
f. Graphic maps or drawings containing inputs, outputs, and override groups shall include the following:
1) Database to import and store full-color maps or drawings and allow for input, output, and override group icons to be placed on maps.
2) Maps to provide real-time display animation and allow for control of points assigned to them.
3) System to allow inputs, outputs, and override groups to be placed on different maps.
4) Software to allow changing the order or priority in which maps will be displayed.
g. Override Groups Containing I/Os:
1) System shall incorporate override groups that provide the operator with the status and control over user-defined "sets" of I/Os with a single icon.
2) Icon shall change automatically to show the live summary status of points in that group.
3) Override group icon shall provide a method to manually control or set to time-zone points in the group.
4) Override group icon shall allow the expanding of the group to show icons representing the live status for each point in the group, individual control over each point, and the ability to compress the individual icons back into one summary icon.
h. Schedule Overrides of I/Os and Override Groups:
1) To accommodate temporary schedule changes that do not fall within the holiday parameters, the operator shall have the ability to override schedules individually for each input, output, or override group.
2) Each schedule shall be composed of a minimum of two dates with separate times for each date.
3) The first time and date shall be assigned the override state that the point shall advance to when the time and date become current.
4) The second time and date shall be assigned the state that the point shall return to when the time and date become current.
i. Copy command in database shall allow for like data to be copied and then edited for specific requirements, to reduce redundant data entry.

12. Operator Access Control:
a. Control operator access to system controls through three password-protected operator levels. System operators and managers with appropriate password clearances shall be able to change operator levels for operators.
b. Three successive attempts by an operator to execute functions beyond their defined level during a 24-hour period shall initiate a software tamper alarm.
c. A minimum of 32 passwords shall be available with the system software. System shall display the operator's name or initials in the console's first field. System shall print the operator's name or initials, action, date, and time on the system printer at login and logoff.

d. The password shall not be displayed or printed.
e. Each password shall be definable and assignable for the following:
   1) Selected commands to be usable.
   2) Access to system software.
   3) Access to application software.
   4) Individual zones that are to be accessed.
   5) Access to database.

13. Operator Commands:
   a. Command Input: Plain-language words and acronyms shall allow operators to use the system without extensive training or data-processing backgrounds. System prompts shall be a word, a phrase, or an acronym.
   b. Command inputs shall be acknowledged and processing shall start in not less than one second(s).
   c. Tasks that are executed by operator's commands shall include the following:
      1) Acknowledge Alarms: Used to acknowledge that the operator has observed the alarm message.
      2) Place Zone in Access: Used to remotely disable intrusion-alarm circuits emanating from a specific zone. System shall be structured so that console operator cannot disable tamper circuits.
      3) Place Zone in Secure: Used to remotely activate intrusion-alarm circuits emanating from a specific zone.
      4) System Test: Allows the operator to initiate a system-wide operational test.
      5) Zone Test: Allows the operator to initiate an operational test for a specific zone.
      6) Print reports.
      7) Change Operator: Used for changing operators.
      8) Security Lighting Controls: Allows the operator to remotely turn on or turn off security lights.
      9) Display Graphics: Used to show any graphic displays implemented in the system. Graphic displays shall be completed within 20 seconds from time of operator command.
      10) Run system tests.
      11) Generate and format reports.
      12) Request help with the system operation.
         a) Include in main menus.
         b) Provide unique, descriptive, context-sensitive help for selections and functions with the press of one function key.
         c) Provide navigation to specific topic from within the first help window.
         d) Help shall be accessible outside the application program.
      13) Entry-Control Commands:
         a) Lock (secure) or unlock (open) each controlled entry and exit up to four times a day through time-zone programming.
         b) Arm or disarm each monitored input up to four times a day through time-zone programming.
         c) Enable or disable readers or keypads up to two times a day through time-zone programming.
         d) Enable or disable cards or codes up to four times a day per entry point through access-level programming.
   d. Command Input Errors: Show operator input assistance when a command cannot be executed because of operator input errors. Assistance screen shall use plain-language words and phrases to explain why the command cannot be executed. Error responses that require an operator to look up a code in a manual or other document are not acceptable. Conditions causing operator assistance messages include the following:
      1) Command entered is incorrect or incomplete.
      2) Operator is restricted from using that command.
      3) Command addresses a point that is disabled or out of service.

4) Command addresses a point that does not exist.
5) Command is outside the system's capacity.

14. Alarms:
    a. System Setup:
        1) Assign manual and automatic responses to incoming-point status change or alarms.
        2) Automatically respond to input with a link to other inputs, outputs, or operator-response plans; unique sound with use of WAV files; and maps or images that graphically represent the point location.
        3) Sixty-character message field for each alarm.
        4) Operator-response-action messages shall allow message length of at least 65,000 characters, with database storage capacity of up to 32,000 messages. Setup shall assign messages to access point **OR** zone **OR** sensor**, as directed**.
        5) Secondary messages shall be assignable by the operator for printing to provide further information and shall be editable by the operator.
        6) Allow 25 secondary messages with a field of four lines of 60 characters each.
        7) Store the most recent 1000 alarms for recall by the operator using the report generator.
    b. Software Tamper:
        1) Annunciate a tamper alarm when unauthorized changes to system database files are attempted. Three consecutive unsuccessful attempts to log onto system shall generate a software tamper alarm.
        2) Annunciate a software tamper alarm when an operator or other individual makes three consecutive unsuccessful attempts to invoke functions beyond the authorization level.
        3) Maintain a transcript file of the last 5000 commands entered at each central station to serve as an audit trail. System shall not allow write access to system transcript files by any person, regardless of their authorization level.
        4) Allow only acknowledgment of software tamper alarms.
    c. Read access to system transcript files shall be reserved for operators with the highest password authorization level available in system.
    d. Animated Response Graphics: Highlight alarms with flashing icons on graphic maps; display and constantly update the current status of alarm inputs and outputs in real time through animated icons.
    e. Multimedia Alarm Annunciation: WAV files to be associated with alarm events for audio annunciation or instructions.
    f. Alarm Handling: Each input may be configured so that an alarm cannot be cleared unless it has returned to normal, with options of requiring the operator to enter a comment about disposition of alarm. Allow operator to silence alarm sound when alarm is acknowledged.
    g. Alarm Automation Interface: High-level interface to central-station alarm automation software systems. Allows input alarms to be passed to and handled by automation systems in the same manner as burglar alarms, using a TIA 232-F ASCII interface.
    h. CCTV Alarm Interface: Allow commands to be sent to CCTV systems during alarms (or input change of state) through serial ports.
    i. Camera Control: Provides operator ability to select and control cameras from graphic maps.
15. Alarm Monitoring: Monitor sensors, controllers, and DTS circuits and notify operators of an alarm condition. Display higher-priority alarms first and, within alarm priorities, display the oldest unacknowledged alarm first. Operator acknowledgment of one alarm shall not be considered acknowledgment of other alarms nor shall it inhibit reporting of subsequent alarms.
    a. Displayed alarm data shall include type of alarm, location of alarm, and secondary alarm messages.
    b. Printed alarm data shall include type of alarm, location of alarm, date and time (to nearest second) of occurrence, and operator responses.
    c. Maps shall automatically display the alarm condition for each input assigned to that map if that option is selected for that input location.

d. Alarms initiate a status of "pending" and require the following two handling steps by operators:
   1) First Operator Step: "Acknowledged." This action shall silence sounds associated with the alarm. The alarm remains in the system "Acknowledged" but "Un-Resolved."
   2) Second Operator Step: Operators enter the resolution or operator comment, giving the disposition of the alarm event. The alarm shall then clear.
e. Each workstation shall display the total pending alarms and total unresolved alarms.
f. Each alarm point shall be programmable to disallow the resolution of alarms until the alarm point has returned to its normal state.
g. Alarms shall transmit to the central station in real time except for allowing connection time for dial-up locations.
h. Alarms shall be displayed and managed from a minimum of four different windows.
   1) Input Status Window: Overlay status icon with a large red blinking icon. Selecting the icon will acknowledge the alarm.
   2) History Log Transaction Window: Display name, time, and date in red text. Selecting red text will acknowledge the alarm.
   3) Alarm Log Transaction Window: Display name, time, and date in red. Selecting red text will acknowledge the alarm.
   4) Graphic Map Display: Display a steady colored icon representing each alarm input location. Change icon to flashing red when the alarm occurs. Change icon from flashing red to steady red when the alarm is acknowledged.
i. Once an alarm is acknowledged, the operator shall be prompted to enter comments about the nature of the alarm and actions taken. Operator's comments may be manually entered or selected from a programmed predefined list, or a combination of both.
j. For locations where there are regular alarm occurrences, provide programmed comments. Selecting that comment shall clear the alarm.
k. The time and name of the operator who acknowledged and resolved the alarm shall be recorded in the database.
l. Identical alarms from the same alarm point shall be acknowledged at the same time the operator acknowledges the first alarm. Identical alarms shall be resolved when the first alarm is resolved.
m. Alarm functions shall have priority over downloading, retrieving, and updating database from workstations and controllers.
n. When a reader-controlled output (relay) is opened, the corresponding alarm point shall be automatically bypassed.

16. Monitor Display: Display text and graphic maps that include zone status integrated into the display. Colors are used for the various components and current data. Colors shall be uniform throughout the system.
   a. Color Code:
      1) FLASHING RED: Alerts operator that a zone has gone into an alarm or that primary power has failed.
      2) STEADY RED: Alerts operator that a zone is in alarm and alarm has been acknowledged.
      3) YELLOW: Advises operator that a zone is in access.
      4) GREEN: Indicates that a zone is secure and that power is on.
   b. Graphics:
      1) Support 32,000 graphic display maps and allow import of maps from a minimum of 16 standard formats from another drawing or graphics program.
      2) Allow I/O to be placed on graphic maps by the drag-and-drop method.
      3) Operators shall be able to view the inputs, outputs, and the point's name by moving the mouse cursor over the point on the graphic map.
      4) Inputs or outputs may be placed on multiple graphic maps. The operator shall be able to toggle to view graphic maps associated with I/Os.

5) Each graphic map shall have a display-order sequence number associated with it to provide a predetermined order when toggled to different views.
6) Camera icons shall have the ability to be placed on graphic maps that, when selected by an operator, will open a video window, display the camera associated with that icon, and provide pan-tilt-zoom control.
7) Input, output, or camera placed on a map shall allow the ability to arm or bypass an input, open or secure an output, or control the pan-tilt-zoom function of the selected camera.

17. System test software enables operators to initiate a test of the entire system or of a particular portion of the system.
    a. Test Report: The results of each test shall be stored for future display or printout. The report shall document the operational status of system components.
18. Report-Generator Software: Include commands to generate reports for displaying, printing, and storing on disk and tape. Reports shall be stored by type, date, and time. Report printing shall be the lowest-priority activity. Report-generation mode shall be operator selectable but set up initially as periodic, automatic, or on request. Include time and date printed and the name of operator generating the report. Report formats may be configured by operators.
    a. Automatic Printing: Setup shall specify, modify, or inhibit the report to be generated; the time the initial report is to be generated; the time interval between reports; the end of the period; and the default printer.
    b. Printing on Request: An operator may request a printout of any report.
    c. Alarm Reports: Reporting shall be automatic as initially set up. Include alarms recorded by system over the selected time and information about the type of alarm such as door alarm, intrusion alarm, tamper alarm, etc, the type of sensor, the location, the time, and the action taken.
    d. Access and Secure Reports: Document zones placed in access, the time placed in access, and the time placed in secure mode.
    e. Custom Reports: Reports tailored to exact requirements of who, what, when, and where. As an option, custom report formats may be stored for future printing.
    f. Automatic History Reports: Named, saved, and scheduled for automatic generation.
    g. Cardholder Reports: Include data, or selected parts of the data, as well as the ability to be sorted by name, card number, imprinted number, or by any of the user-defined fields.
    h. Cardholder by Reader Reports: Based on who has access to a specific reader or group of readers by selecting the readers from a list.
    i. Cardholder by Access-Level Reports: Display everyone that has been assigned to the specified access level.
    j. Who Is "In" (Muster) Report:
        1) Emergency Muster Report: One-click operation on toolbar launches report.
        2) Cardholder Report. Contain a count of persons who are "In" at a selected Location and a detailed listing of name, date, and time of last use, sorted by the last reader used or by the group assignment.
    k. Panel Labels Reports: Printout of control-panel field documentation including the actual location of equipment, programming parameters, and wiring identification. Maintain system installation data within system database so that data are available on-site at all times.
    l. Activity and Alarm On-Line Printing: Activity printers for use at workstations; prints all events, or alarms only.
    m. History Reports: Custom reports that allow the operator to select any date, time, event type, device, output, input, operator, Location, name, or cardholder to be included or excluded from the report.
        1) Initially store history on the hard disk of the host PC.
        2) Permit viewing of the history on workstations or print history to any system printer.
        3) The report shall be definable by a range of dates and times with the ability to have a daily start and stop time over a given date range.
        4) Each report shall depict the date, time, event type, event description, and device; or I/O name, cardholder group assignment, and cardholder name or code number.

5) Each line of a printed report shall be numbered to ensure that the integrity of the report has not been compromised.
6) Total number of lines of the report shall be given at the end of the report. If the report is run for a single event such as "Alarms," the total shall reflect how many alarms occurred during that period.

n. Reports shall have the following four options:
1) View on screen.
2) Print to system printer. Include automatic print spooling and "Print To" options if more than one printer is connected to the system.
3) "Save to File" with full path statement.
4) System shall have the ability to produce a report indicating status of system inputs and outputs or of inputs and outputs that are abnormal, out of time zone, manually overridden, not reporting, or in alarm.

o. Custom Code List Subroutine: Allow the access codes of system to be sorted and printed according to the following criteria:
1) Active, inactive, or future activate or deactivate.
2) Code number, name, or imprinted card number.
3) Group, Location access levels.
4) Start and stop code range.
5) Codes that have not been used since a selectable number of days.
6) In, out, or either status.
7) Codes with trace designation.

p. The reports of system database shall allow options so that every data field may be printed.

q. The reports of system database shall be constructed so that the actual position of the printed data shall closely match the position of the data on the data-entry windows.

19. Anti-Passback:

a. System shall have global and local anti-passback features, selectable by Location. System shall support hard and soft anti-passback.

b. Hard Anti-Passback: Once a credential holder is granted access through a reader with one type of designation (IN or OUT), the credential holder may not pass through that type of reader designation until the credential holder passes through a reader of opposite designation.

c. Soft Anti-Passback: Should a violation of the proper IN or OUT sequence occur, access shall be granted, but a unique alarm shall be transmitted to the control station, reporting the credential holder and the door involved in the violation. A separate report may be run on this event.

d. Timed Anti-Passback: A controller capability that prevents an access code from being used twice at the same device (door) within a user-defined amount of time.

e. Provide four separate zones per Location that can operate without requiring interaction with the host PC (done at controller). Each reader shall be assignable to one or all four anti-passback zones. In addition, each anti-passback reader can be further designated as "Hard," "Soft," or "Timed" in each of the four anti-passback zones. The four anti-passback zones shall operate independently.

f. The anti-passback schemes shall be definable for each individual door.

g. The Master Access Level shall override anti-passback.

h. System shall have the ability to forgive (or reset) an individual credential holder or the entire credential-holder population anti-passback status to a neutral status.

20. Visitor Assignment:

a. Provide for and allow an operator to be restricted to only working with visitors. The visitor badging subsystem shall assign credentials and enroll visitors. Allow only those access levels that have been designated as approved for visitors.

b. Provide an automated log of visitor name, time and doors accessed, and name of person contacted.

c. Allow a visitor designation to be assigned to a credential holder.

d. Security access system shall be able to restrict the access levels that may be assigned to credentials issued to visitors.
e. Allow operator to recall visitors' credential-holder file once a visitor is enrolled in the system.
f. The operator may designate any reader as one that deactivates the credential after use at that reader. The history log shall show the return of the credential.
g. System shall have the ability to use the visitor designation in searches and reports. Reports shall be able to print all or any visitor activity.

21. Time and Attendance:
    a. Time and attendance reporting shall be provided to match IN and OUT reads and display cumulative time in for each day and cumulative time in for length designated in the report.
    b. Shall be provided to match IN and OUT reads and display cumulative time in for each day and cumulative time in for length designated in the report.
    c. System software setup shall allow designation of selected access-control readers as time and attendance hardware to gather the clock-in and clock-out times of the users at these readers.
        1) Reports shall show in and out times for each day, total time in for each day, and a total time in for period specified by the user.
        2) Allow the operator to view and print the reports, or save the reports to a file.
        3) Alphabetically sort reports on the person's last name, by Location or location group. Include all credential holders or optionally select individual credential holders for the report.
22. Training Software: Enables operators to practice system operation, including alarm acknowledgment, alarm assessment, response force deployment, and response force communications. System shall continue normal operation during training exercises and shall terminate exercises when an alarm signal is received at the console.
23. Entry-Control Enrollment Software: Database management functions that allow operators to add, delete, and modify access data as needed.
    a. The enrollment station shall not have alarm response or acknowledgment functions.
    b. Provide multiple, password-protected access levels. Database management and modification functions shall require a higher operator access level than personnel enrollment functions.
    c. The program shall provide means to disable the enrollment station when it is unattended, to prevent unauthorized use.
    d. The program shall provide a method to enter personnel identifying information into the entry-control database files through enrollment stations. In the case of personnel identity-verification subsystems, this shall include biometric data. Allow entry of personnel identifying information into the system database using menu selections and data fields. The data field names shall be customized during setup to suit user and site needs. Personnel identity-verification subsystems selected for use with the system shall fully support the enrollment function and shall be compatible with the entry-control database files.
    e. Cardholder Data: Provide 99 user-defined fields. System shall have the ability to run searches and reports using any combination of these fields. Each user-defined field shall be configurable, using any combination of the following features:
        1) MASK: Determines a specific format with which data must comply.
        2) REQUIRED: Operator is required to enter data into field before saving.
        3) UNIQUE: Data entered must be unique.
        4) DEACTIVATE DATE: Data entered will be evaluated as an additional deactivate date for all cards assigned to this cardholder.
        5) NAME ID: Data entered will be considered a unique ID for the cardholder.
    f. Personnel Search Engine: A report generator with capabilities such as search by last name, first name, group, or any predetermined user-defined data field; by codes not used in definable number of days; by skills; or by seven other methods.
    g. Multiple Deactivate Dates for Cards: User-defined fields to be configured as additional stop dates to deactivate any cards assigned to the cardholder.

h. Batch card printing.
i. Default card data can be programmed to speed data entry for sites where most card data are similar.
j. Enhanced ASCII File Import Utility: Allows the importing of cardholder data and images.
k. Card Expire Function: Allows readers to be configured to deactivate cards when a card is used at selected devices.

D. System Database
1. Database and database management software shall define and modify each point in database using operator commands. Definition shall include parameters and constraints associated with each system device.
2. Database Operations:
a. System data management shall be in a hierarchical menu tree format, with navigation through expandable menu branches and manipulated with use of menus and icons in a main menu and system toolbar.
b. Navigational Aids:
1) Toolbar icons for add, delete, copy, print, capture image, activate, deactivate, and muster report.
2) Point and click feature to facilitate data manipulation.
3) Next and previous command buttons visible when editing database fields to facilitate navigation from one record to the next.
4) Copy command and copy tool in the toolbar to copy data from one record to create a new similar record.
c. Data entry shall be automatically checked for duplicate and illegal data and shall verify that data are in a valid format.
d. System shall generate a memo or note field for each item that is stored in database, allowing the storing of information about any defining characteristics of the item. Memo field is used for noting the purpose the item was entered for, reasons for changes that were made, and the like.
3. File Management:
a. File management shall include backup and restoration system, allowing selection of storage media, including 3.5-inch floppy disk, Zip and Jaz drives, and designated network resources.
b. Operations shall be both manual and automatic mode. The number of automatic sequential backups before the oldest backup becomes overwritten; FIFO mode shall be operator selectable.
c. Backup program shall provide manual operation from any PC on the LAN and shall operate while system remains operational.
4. Operator Passwords:
a. Software shall support up to 32,000 individual system operators, each with a unique password.
b. One to eight alphanumeric characters.
c. Allow passwords to be case sensitive.
d. Passwords shall not be displayed when entered.
e. Passwords shall have unique and customizable password profile, and allow several operators to share a password profile. Include the following features in the password profile:
1) Allow for at least 32,000 operator password profiles.
2) Predetermine the highest-level password profile for access to all functions and areas of program.
3) Allow or disallow operator access to any program operation, including the functions of View, Add, Edit, and Delete.
4) Restrict which doors an operator can assign access to.

f. Operators shall use a user name and password to log on to system. This user name and password shall be used to access database areas and programs as determined by the associated profile.
g. Make provision to allow the operator to log off without fully exiting program. User may be logged off but program will remain running while displaying the login window for the next operator.

5. Access Card/Code Operation and Management: Access authorization shall be by card, by a manually entered code (PIN), or by a combination of both (card plus PIN).
   a. Access authorization shall verify the facility code first, the card or card-and-PIN validation second, and the access level (time of day, day of week, date), anti-passback status, and number of uses last.
   b. Use data-entry windows to view, edit, and issue access levels. Access authorization entry management system shall maintain and coordinate all access levels to prevent duplication or the incorrect creation of levels.
   c. Allow assignment of multiple cards/codes to a cardholder.
   d. Allow assignment of up to four access levels for each Location to a cardholder. Each access level may contain any combination of doors.
   e. Each door may be assigned four time zones.
   f. Access codes may be up to 11 digits in length.
   g. Software shall allow the grouping of locations so cardholder data can be shared by all locations in the group.
   h. Visitor Access: Issue a visitor badge for data tracking or photo ID purposes without assigning that person a card or code.
   i. Cardholder Tracing: Allow for selection of cardholder for tracing. Make a special audible and visual annunciation at control station when a selected card or code is used at a designated code reader. Annunciation shall include an automatic display of the cardholder image.
   j. Allow each cardholder to be given either an unlimited number of uses or a number from 1 to 9998 that regulates the number of times the card can be used before it is automatically deactivated.
   k. Provide for cards and codes to be activated and deactivated manually or automatically by date. Provide for multiple deactivate dates to be preprogrammed.
6. Security Access Integration:
   a. Photo ID badging and photo verification shall use same database as the security access and may query data from cardholder, group, and other personal information to build a custom ID badge.
   b. Automatic or manual image recall and manual access based on photo verification shall also be a means of access verification and entry.
   c. System shall allow sorting of cardholders together by group or other characteristic for a fast and efficient method of reporting on, and enabling or disabling, cards or codes.
7. Key control and tracking shall be an integrated function of cardholder data.
   a. Provide the ability to store information about which conventional metal keys are issued and to whom, along with key construction information.
   b. Reports shall be designed to list everyone that has possession of a specified key.
8. Facility Codes: System shall accommodate up to 2048 facility codes per Location, with the option of allowing facility codes to work at all doors or only particular doors.
9. Operator Comments:
   a. With the press of one appropriate button on toolbar, the user shall be permitted to make operator comments into history at anytime.
   b. Automatic prompting of operator comment shall occur before the resolution of each alarm.
   c. Operator comments shall be recorded by time, date, and operator number.
   d. Comments shall be sorted and viewed through reports and history.
   e. The operator may enter comments in two ways; either or both may be used:
      1) Manually entered through keyboard data entry (typed), up to 65,000 characters per each alarm.
      2) Predefined and stored in database for retrieval on request.

f. System shall have a minimum of 999 predefined operator comments with up to 30 characters per comment.

10. Group:
    a. Group names may be used to sort cardholders into groups that allow the operator to determine the tenant, vendor, contractor, department, division, or any other designation of a group to which the person belongs.
    b. System software shall have the capacity to assign 1 of 32,000 group names to an access authorization.
    c. Make provision in software to deactivate and reactivate all access authorizations assigned to a particular group.
    d. Allow sorting of history reports and code list printouts by group name.
11. Time Zones:
    a. Each zone consists of a start and stop time for 7 days of the week and three holiday schedules. A time zone is assigned to inputs, outputs, or access levels to determine when an input shall automatically arm or disarm, when an output automatically opens or secures, or when access authorization assigned to an access level will be denied or granted.
    b. Up to four time zones may be assigned to inputs and outputs to allow up to four arm or disarm periods per day or four lock or unlock periods per day; up to three holiday override schedules may be assigned to a time zone.
    c. Data-entry window shall display a dynamically linked bar graph showing active and inactive times for each day and holiday, as start and stop times are entered or edited.
    d. System shall have the capacity for 2048 time zones for each Location.
12. Holidays:
    a. Three different holiday schedules may be assigned to a time zone. Holiday schedule consists of date in format MM/DD/YEAR and a description. When the holiday date matches the current date of the time zone, the holiday schedule replaces the time zone schedule for that 24-hour period.
    b. System shall have the capacity for 32,000 holidays.
    c. Three separate holiday schedules may be applied to a time zone.
    d. Holidays have an option to be designated as occurring on the designated date each year. These holidays remain in system and will not be purged.
    e. Holidays not designated to occur each year shall be automatically purged from database after the date expires.
13. Access Levels:
    a. System shall allow for the creation up to 32,000 access levels.
    b. One level shall be predefined as the Master Access Level. The Master Access Level shall work at all doors at all times and override any anti-passback.
    c. System shall allow for access to be restricted to any area by reader and by time. Access levels shall determine when and where an Identifier is authorized.
    d. System shall be able to create multiple door and time zone combinations under same access level so that an Identifier may be valid during different time periods at different readers even if the readers are on the same Controller.
14. User-Defined Fields:
    a. System shall provide a minimum of 99 user-defined fields, each with up to 50 characters, for specific information about each credential holder.
    b. System shall accommodate a title for each field; field length shall be 20 characters.
    c. A "Required" option may be applied to each user-defined field that, when selected, forces the operator to enter data in the user-defined field before the credential can be saved.
    d. A "Unique" option may be applied to each user-defined field that, when selected, will not allow duplicate data from different credential holders to be entered.
    e. Data format option may be assigned to each user-defined field that will require the data to be entered with certain character types in specific spots in the field entry window.
    f. A user-defined field, if selected, will define the field as a deactivate date. The selection shall automatically cause the data to be formatted with the windows MM/DD/YEAR date format. The credential of the holder will be deactivated on that date.

g. A search function shall allow any one user-defined field or combination of user-defined fields to be searched to find the appropriate cardholder. The search function shall include search for a character string.
h. System shall have the ability to print cardholders based on and organized by the user-defined fields.

15. Code Tracing:
a. System shall perform code tracing selectable by cardholder and by reader.
b. Any code may be designated as a "traced code" with no limit to how many codes can be traced.
c. Any reader may be designated as a "trace reader" with no limit to which or how many readers can be used for code tracing.
d. When a traced code is used at a trace reader, the access-granted message that usually appears on the monitor window of the Central Station shall be highlighted with a different color than regular messages. A short singular beep shall occur at the same time the highlighted message is displayed on the window.
e. The traced cardholder image (if image exists) shall appear on workstations when used at a trace reader.

E. Surge And Tamper Protection
1. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor-entry connection to components.
a. Minimum Protection for Power Connections 120 V and More: Auxiliary panel suppressors complying with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits".
b. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Connections: Comply with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits" as recommended by manufacturer for type of line being protected.
2. Tamper Protection: Tamper switches on enclosures, control units, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled. Control-station control-unit alarm display shall identify tamper alarms and indicate locations.

F. Central-Station Hardware
1. Central-Station Computer: Standard unmodified PC of modular design. The CPU word size shall be 32 bytes or larger; the CPU operating speed shall be at least 66 MHz **OR** GHz, **as directed**.
a. Memory: 256 MB of usable installed memory, expandable to a minimum of 1024 MB without additional chassis or power supplies.
b. Power Supply: Minimum capacity of 250 W.
c. Real-Time Clock:
1) Accuracy: Plus or minus 1 minute per month.
2) Time Keeping Format: 24-hour time format including seconds, minutes, hours, date, day, and month; resettable by software.
3) Clock shall function for 1 year without power.
4) Provide automatic time correction once every 24 hours by synchronizing clock with the Time Service Department of the U.S. Naval Observatory.
d. Serial Ports: Provide two TIA 232-F serial ports for general use, with additional ports as required. Data transmission rates shall be selectable under program control.
e. Parallel Port: An enhanced parallel port.
f. LAN Adapter Card: 10/100 Mbps PCI bus, internal network interface card.
g. Sound Card: For playback and recording of digital WAV sound files that are associated with audible warning and alarm functions.
h. Color Monitor: Not less than 17 inches (430 mm), with a minimum resolution of 1280 by 1024 pixels, noninterlaced, and a maximum dot pitch of 0.28 mm. The video card shall

support at least 256 colors at a resolution of 1280 by 1024 at a minimum refresh rate of 70 Hz.

i. Keyboard: With a minimum of 64 characters, standard ASCII character set based on ANSI INCITS 154.

j. Mouse: Standard, compatible with the installed software.

k. Special function keyboard attachments or special function keys to facilitate data input of the following operator tasks:
   1) Help.
   2) Alarm Acknowledge.
   3) Place Zone in Access.
   4) Place Zone in Secure.
   5) System Test.
   6) Print Reports.
   7) Change Operator.

l. Disk storage shall include the following, each with appropriate controller:
   1) Minimum 10 GB hard disk, maximum average access time of 10 ms.
   2) Floppy Disk Drive: High density, 3-1/2-inch (90-mm) size.
   3) PCMCIA slot with removable 500 MB media.
   4) 100 MB Iomega Zip drive.
   5) 250 MB Iomega Jaz drive.

m. Magnetic Tape System: 4-mm cartridge magnetic tape system with minimum 2 **OR** 4 **OR** 12 **OR** 20, **as directed**, GB formatted capacity per tape. Provide 10 tapes, each in a rigid cartridge with spring-loaded cover and operator-settable write-protect feature.

n. Modem: 56,600 bps, full duplex for asynchronous communications. With error detection, auto answer/autodial, and call-in-progress detection. Modem shall comply with requirements in ITU-T v.34, ITU-T v.42 for error correction, and ITU-T v.42 BIS for data compression standards; and shall be suitable for operating on unconditioned voice-grade telephone lines complying with 47 CFR 68.

o. Audible Alarm: Manufacturer's standard.

p. CD-ROM Drive:
   1) Nominal storage capacity of 650 MB.
   2) Data Transfer Rate: 1.2 Mbps.
   3) Average Access Time: 150 ms.
   4) Cache Memory: 256 KB.
   5) Data Throughput: 1 MB/second, minimum.

q. Dot Matrix Alarm Printer:
   1) Connected to the Central Station.
   2) Minimum of 96 characters, standard ASCII character set based on ANSI INCITS 154, and with graphics capability and programmable control of top-of-form.
   3) Prints in both red and black without ribbon change.
   4) Adjustable sprockets for paper width up to 11 inches.
   5) 80 columns per line, minimum speed of 200 characters per second.
   6) Character Spacing: Selectable at 10, 12, or 17 characters per inch.
   7) Paper: Sprocket-fed fan fold paper.

r. Report Printer:
   1) Connected to the Central Station and designated workstations.
   2) Laser printer with minimum resolution of 600 dpi.
   3) RAM: 2 MB, minimum.
   4) Printing Speed: Minimum 12 pages per minute.
   5) Paper Handling: Automatic sheet feeder with 250-sheet paper cassette and with automatic feed.

s. Interface: Bidirectional parallel and universal serial bus.

t. LAN Adapter Card: 10/100 Mbps internal network interface card.

2. Redundant Central Computer: One identical redundant central computer, connected in a hot standby, peer configuration. This computer shall automatically maintain its own copies of system

software, application software, and data files. System transactions and other activities that alter system data files shall be updated to system files of redundant computer in near real-time. If central computer fails, redundant computer shall assume control immediately and automatically.

3. UPS: Self-contained; complying with requirements in Division 26 Section "Static Uninterruptible Power Supply".
   a. Size: Provide a minimum of 6 hours of operation of the central-station equipment, including 2 hours of alarm printer operation.
   b. Batteries: Sealed, valve regulated, recombinant, lead calcium.
   c. Accessories:
      1) Transient voltage suppression.
      2) Input-harmonics reduction.
      3) Rectifier/charger.
      4) Battery disconnect device.
      5) Static bypass transfer switch.
      6) Internal maintenance bypass/isolation switch.
      7) External maintenance bypass/isolation switch.
      8) Output isolation transformer.
      9) Remote UPS monitoring.
      10) Battery monitoring.
      11) Remote battery monitoring.

G. Standard Workstation Hardware
   1. Workstation shall consist of a standard unmodified PC, with accessories and peripherals that configure the workstation for a specific duty.
   2. Workstation Computer: Standard unmodified PC of modular design. The CPU word size shall be 32 bytes or larger; the CPU operating speed shall be at least 66 MHz **OR** GH, **as directed**.
      a. Memory: 512 MB of usable installed memory, expandable to a minimum of 8 GB without additional chassis or power supplies.
      b. Power Supply: Minimum capacity of 250 W.
      c. Real-Time Clock:
         1) Accuracy: Plus or minus 1 minute per month.
         2) Time Keeping Format: 24-hour time format including seconds, minutes, hours, date, day, and month; resettable by software.
         3) Provide automatic time correction once every 24 hours by synchronizing clock with the Central Station.
      d. Serial Ports: Provide two TIA 232-F USB serial ports for general use, with additional ports as required. Data transmission rates shall be selectable under program control.
      e. Parallel Port: An enhanced parallel port.
      f. Sound Card: For playback and recording of digital WMP sound files that are associated with audible warning and alarm functions.
      g. Color Monitor: Not less than 17 inches (430 mm), with a minimum resolution of 1280 by 1024 pixels, noninterlaced, and a maximum dot pitch of 0.28 mm. The video card shall support at least 256 colors at a resolution of 1280 by 1024 at a minimum refresh rate of 70 Hz.
      h. Keyboard: With a minimum of 64 characters, standard ASCII character set based on ANSI INCITS 154.
      i. Mouse: Standard, compatible with the installed software. Minimum resolution shall be 400 dpi.
      j. Disk storage shall include the following, each with appropriate controller:
         1) Minimum 20 GB hard disk, maximum average access time of 10 ms.
         2) Floppy Disk Drive: High density, 3-1/2-inch (90-mm) size.
      k. CD-ROM Drive:
         1) Nominal storage capacity of 700 MB.
         2) Data Transfer Rate: 3.6 Mbps.
         3) Average Access Time: 150 ms.
         4) Cache Memory: 512 KB.

5) Data Throughput: 3.6 MB/second, minimum.
6) Read Speed: 48x.
7) Write Speed: 32x.

l. DVD/DVD-RW Drive:
1) Nominal Storage Capacity: 4.7 GB.
2) Data Transfer Rate: 3.6 Mbps.
3) Cache Memory: 512 KB.
4) Read Speed: 24x.
5) Write Speed: 6x.

m. Printer:
1) Connected to the Central Station and designated workstations.
2) Laser printer with minimum resolution of 600 dpi.
3) RAM: 8 MB, minimum.
4) Printing Speed: Minimum 12 pages per minute.
5) Paper Handling: Automatic sheet feeder with 250-sheet paper cassette and with automatic feed.

n. Interface: Bidirectional parallel, and universal serial bus.
o. LAN Adapter Card: 10/100 Mbps internal network interface card.

3. Redundant Workstation: One identical redundant workstation, connected in a hot standby, peer configuration. This workstation shall automatically maintain its own copies of system software, application software, and data files. System transactions and other activities that alter system data files shall be updated to system files of redundant workstation in near real time. If its associated workstation fails, redundant workstation shall assume control immediately and automatically.
4. UPS: Self-contained, complying with requirements in Division 26 Section "Static Uninterruptible Power Supply".
a. Size: Provide a minimum of 6 hours of operation of the central-station equipment, including 2 hours of alarm printer operation.
b. Batteries: Sealed, valve regulated, recombinant, lead calcium.
c. Accessories:
1) Transient voltage suppression.
2) Input-harmonics reduction.
3) Rectifier/charger.
4) Battery disconnect device.
5) Static bypass transfer switch.
6) Internal maintenance bypass/isolation switch.
7) External maintenance bypass/isolation switch.
8) Output isolation transformer.
9) Remote UPS monitoring.
10) Battery monitoring.
11) UPS operation monitoring.
12) Abnormal operation. Visible and audible indication.
13) Remote battery monitoring.

H. Communications Workstation
1. Standard workstation, modified as follows:
a. Additional TIA 232-F serial ports. The CPU word size shall be 32 bytes or larger; the CPU operating speed shall be at least 66 MHz. Multiplexed serial ports shall be expandable with 8 character transmit and receive buffers for each port. Total buffer size shall be a minimum of 1 MB.
b. Redundant workstation is not required.
c. Printer is not required.

I. Fixed Map Display: A fixed map display shall show layout of the protected facilities. Zones corresponding to those monitored by system shall be highlighted on the display. Status of each zone

shall be displayed using LEDs as required within each designated zone. An LED test switch shall be provided on the map display.

J. Controllers
1. Controllers: Intelligent peripheral control unit, complying with UL 294, that stores time, date, valid codes, access levels, and similar data downloaded from the Central Station or workstation for controlling its operation.
2. Subject to compliance with requirements in this Article, manufacturers may use multipurpose Controllers.
3. Battery Backup: Sealed, lead acid; sized to provide run time during a power outage of 90 minutes, complying with UL 924.
4. Alarm Annunciation Controller:
   a. The Controller shall automatically restore communication within 10 seconds after an interruption with the field device network with dc line supervision on each of its alarm inputs.
      1) Inputs: Monitor dry contacts for changes of state that reflect alarm conditions. Provides at least eight alarm inputs, which are suitable for wiring as normally open or normally closed contacts for alarm conditions.
      2) Alarm-Line Supervision:
         a) Supervise the alarm lines by monitoring each circuit for changes or disturbances in the signal, and for conditions as described in UL 1076 for line security equipment **OR** by monitoring for abnormal open, grounded, or shorted conditions, **as directed**, using dc change measurements. System shall initiate an alarm in response to an abnormal current, which is a dc change of 5 **OR** 10, **as directed**, percent or more for longer than 500 ms.
         b) Transmit alarm-line-supervision alarm to the Central Station during the next interrogation cycle after the abnormal current condition.
      3) Outputs: Managed by Central Station software.
   b. Auxiliary Equipment Power: A GFI service outlet inside the Controller enclosure.
5. Entry-Control Controller:
   a. Function: Provide local entry-control functions including one- and two-way communications with access-control devices such as card readers, keypads, biometric personal identity verification devices, door strikes, magnetic latches, gate and door operators, and exit push-buttons.
      1) Operate as a stand-alone portal Controller using the downloaded database during periods of communication loss between the Controller and the field-device network.
      2) Accept information generated by the entry-control devices; automatically process this information to determine valid identification of the individual present at the portal:
         a) On authentication of the credentials or information presented, check privileges of the identified individual, allowing only those actions granted as privileges.
         b) Privileges shall include, but not be limited to, time of day control, day of week control, group control, and visitor escort control.
      3) Maintain a date-, time-, and Location-stamped record of each transaction. A transaction is defined as any successful or unsuccessful attempt to gain access through a controlled portal by the presentation of credentials or other identifying information.
   b. Inputs:
      1) Data from entry-control devices; use this input to change modes between access and secure.
      2) Database downloads and updates from the Central Station that include enrollment and privilege information.
   c. Outputs:
      1) Indicate success or failure of attempts to use entry-control devices and make comparisons of presented information with stored identification information.
      2) Grant or deny entry by sending control signals to portal-control devices and mask intrusion alarm annunciation from sensors stimulated by authorized entries.

3) Maintain a date-, time-, and Location-stamped record of each transaction and transmit transaction records to the Central Station.
4) Door Prop Alarm: If a portal is held open for longer than 20 seconds **OR** time listed in a schedule, **as directed**, alarm sounds.

d. With power supplies sufficient to power at voltage and frequency required for field devices and portal-control devices.

e. Data Line Problems: For periods of loss of communications with Central Station, or when data transmission is degraded and generating continuous checksum errors, the Controller shall continue to control entry by accepting identifying information, making authentication decisions, checking privileges, and controlling portal-control devices.
1) Store up to 1000 transactions during periods of communication loss between the Controller and access-control devices for subsequent upload to the Central Station on restoration of communication.

f. Controller Power: NFPA 70, Class II power supply transformer, with 12- or 24-V ac secondary, backup battery and charger.
1) Backup Battery: Premium, valve-regulated, recombinant-sealed, lead-calcium battery; spill proof; with a full 1-year warranty and a pro rata 19-year warranty. With single-stage, constant-voltage-current, limited battery charger, comply with battery manufacturer's written instructions for battery terminal voltage and charging current recommendations for maximum battery life.
2) Backup Battery: Valve-regulated, recombinant-sealed, lead-acid battery; spill proof. With single-stage, constant-voltage-current, limited battery charger, comply with battery manufacturer's written instructions for battery terminal voltage and charging current recommendations for maximum battery life.
3) Backup Power Supply Capacity: 5 **OR** 90, **as directed**, minutes of battery supply. Submit battery and charger calculations.
4) Power Monitoring: Provide manual dynamic battery load test, initiated and monitored at the control center; with automatic disconnection of the Controller when battery voltage drops below Controller limits. Report by using local Controller-mounted LEDs and by communicating status to Central Station. Indicate and report the following:
a) Trouble Alarm: Normal power off load assumed by battery.
b) Trouble Alarm: Low battery.
c) Alarm: Power off.

K. Secondary Alarm Annunciator
1. Secondary Alarm Annunciation Site: A workstation with limited I/O capacity, consisting of a secondary alarm annunciation workstation to allow the operator to duplicate functions of the main operator interface, and to show system status changes **OR** to display alarms or system status changes only, **as directed**.

L. Card Readers, Credential Cards, And Keypads
1. Card-Reader Power: Powered from its associated controller, including its standby power source, and shall not dissipate more than 5 W.
2. Response Time: Card reader shall respond to passage requests by generating a signal that is sent to the controller. Response time shall be 800 ms or less, from the time the card reader finishes reading the credential card until a response signal is generated.
3. Enclosure: Suitable for surface, semi-flush, pedestal, or weatherproof mounting. Mounting types shall additionally be suitable for installation in the following locations:
a. Indoors, controlled environment.
b. Indoors, uncontrolled environment.
c. Outdoors, with built-in heaters or other cold-weather equipment to extend the operating temperature range as needed for operation at the site.

4. Display: Digital visual indicator shall provide visible and audible status indications and user prompts. Indicate power on or off, whether user passage requests have been accepted or rejected, and whether the door is locked or unlocked.
5. Stripe Swipe Readers: Bidirectional, reading cards swiped in both directions, powered by the controller. Reader shall be set up for ABA Track.
   a. ABA Track: Magnetic stripe that is encoded on track 2, at 75-bpi density in binary-coded decimal format; for example, 5-bit, 16-character set.
   b. Readers for outdoors shall be in a polymeric plastic enclosure with all electronics potted in plastic. Rated for operation in ambient conditions of minus 40 to plus 160 deg F (minus 40 to plus 70 deg C) in a humidity range of 10 to 90 percent.
6. Wiegand Swipe Reader: Set up for 33 **OR** 26-bit data cards, **as directed.** Comply with SIA AC-01.
7. Wiegand Key-Insert Reader: Set up for 33 **OR** 26-bit data cards, **as directed.**
8. Bar-Code Reader: Set up for Code 39 **OR** 93 **OR** 128**, as directed.**
9. Insert Readers: Requiring the card to be inserted from the bottom **OR** side, **as directed,** powered by the controller.
10. Touch-Plate and Proximity Readers:
    a. Active-detection proximity card readers shall provide power to compatible credential cards through magnetic induction, and shall receive and decode a unique identification code number transmitted from the credential card.
    b. Passive-detection proximity card readers shall use a swept-frequency, RF field generator to read the resonant frequencies of tuned circuits laminated into compatible credential cards. The resonant frequencies read shall constitute a unique identification code number.
    c. The card reader shall read proximity cards in a range from direct contact to at least 6 inches (150 mm) from the reader.
11. Keypads:
    a. Entry-control keypads shall use a unique combination of alphanumeric and other symbols as an Identifier.
    b. Keypads shall contain an integral alphanumeric/special symbols keyboard with symbols arranged in ascending ASCII-code ordinal sequence **OR** random scrambled order, **as directed.**
    c. Communication protocol shall be compatible with the local processor.
12. Keypad Display:
    a. Keypads shall include a digital visual indicator and shall provide visible **OR** visible and audible status indications and user prompts, **as directed.**
    b. Display shall indicate power on or off and whether user passage requests have been accepted or rejected.
    c. Design of the keypad display or keypad enclosure shall limit viewing angles of the keypad as follows:
       1) Maximum Horizontal Viewing Angle: Plus or minus 5 degrees or less off a vertical plane perpendicular to the plane of the face of the keypad display.
       2) Maximum Vertical Viewing Angle: Plus or minus 15 degrees or less off a horizontal plane perpendicular to the plane of the face of the keypad display.
13. Keypad Response Time:
    a. The keypad shall respond to passage requests by generating a signal to the local processor. The response time shall be 800 ms or less from the time the last alphanumeric symbol is entered until a response signal is generated.
14. Keypad Power:
    a. The keypad shall be powered from the source as shown and shall not dissipate more than 150 W.
15. Keypad Mounting Method:
    a. Keypads shall be suitable for surface, semi-flush, pedestal, or weatherproof mounting as required.
16. Keypad Duress Codes:
    a. Keypads shall provide a means for users to indicate a duress situation by entering a special code.

17. Keypad and Wiegand-Swipe-Reader Combination: Designed to require an entry on the keypad before presenting the credential card.
    a. Keypad: Allow the entry of four numeric digits **OR** alphanumeric characters, **as directed,** that are associated with a specific credential. Keypads shall contain an integral alphanumeric/special symbol keyboard with symbols arranged in ascending ASCII-code ordinal sequence **OR** random scrambled order, **as directed**. Keypad display or enclosure shall limit viewing angles of the keypad as follows:
        1) Maximum Horizontal Viewing Angle: Plus or minus 5 degrees or less off a vertical plane perpendicular to the plane of the face of the keypad display.
        2) Maximum Vertical Viewing Angle: Plus or minus 15 degrees or less off a horizontal plane perpendicular to the plane of the face of the keypad display.
    b. Wiegand Swipe Reader: Set up for 33 OR 26-bit data cards, **as directed**, to generate a unique card identification code. Comply with SIA AC-01.
18. Communication Protocol: Compatible with local processor.
19. Touch-Plate and Contactless Card Reader: The reader shall have "flash" download capability to accommodate card format changes. The card reader shall have capability of transmitting data to security control panel and shall comply with ISO/IEC 7816.
20. Credential Card Modification: Entry-control cards shall be able to be modified by lamination direct print process during the enrollment process without reduction of readability. The design of the credential cards shall allow for the addition of at least one slot or hole to accommodate the attachment of a clip for affixing the credential card to the badge holder used at the site.
21. Specify the standard card size of 2-1/8 by 3-3/8 inches (54 by 85 mm) unless a different size card is needed. If a nonstandard size card is specified, verify that the card size will work with the photo badging system and the card reader specified.
22. Card Size and Dimensional Stability: Credential cards shall be **2-1/8 by 3-3/8 inches (54 by 86 mm)**. The credential card material shall be dimensionally stable so that an undamaged card with deformations resulting from normal use shall be readable by the card reader.
23. Card Material: Abrasion resistant, nonflammable, nontoxic, and impervious to solar radiation and effects of ultraviolet light.
24. Insert additional security enhancements in paragraph below if needed. Retain card lamination and assembly equipment if needed at the site.
25. Card Construction:
    a. Core and laminate or monolithic construction.
    b. Lettering, logos, and other markings shall be hot stamped into the credential material or direct printed.
    c. Incorporate holographic images **OR** phosphorous ink**, as directed,** as a security enhancement.
    d. Furnish equipment for on-site assembly and lamination of credential cards.

M. Biometric Identity Verification Equipment
1. Biometric identity verification templates shall be stored as part of system database files and used as a comparative base by the identity verification equipment to generate an appropriate signal to the associated Controller.
2. Eye Retina Scanner: Designed to incorporate positive measures to establish that the eye retina being scanned by the device belongs to a living human being.
    a. Scanner shall not require eye contact with the retina scan equipment. Scan initiation shall be manual.
    b. The efficiency and accuracy of scanner shall not be affected by contact lenses.
    c. Storage space of each eye template shall not exceed 512 8-bit bytes.
    d. Light-emitting source used for retina scans may not use light levels exceeding 20 percent of the maximum safe level established in the American Conference of Governmental Industrial Hygienists limit values.
    e. Template Update: Eye scanner shall not automatically update a user's template. Significant changes in an individual's eye shall require re-enrollment.

f. Scan acceptance tolerance or template match criteria shall be under system manager/operator control. Eye scanner shall determine automatically when multiple attempts are needed to verify the eye being scanned, prompting automatically for additional attempts, up to a maximum of three. Three failed attempts shall generate an entry-control alarm.

g. Time of Verification: Eye scanner shall respond to passage requests by generating an entry request signal to the Controller. The verification time shall be 1.5 seconds or less from the moment eye scanner initiates the scan process until eye scanner generates a response signal.

h. Modes: Eye scanner shall provide an enrollment mode, a recognition mode, and a code/credential verification mode.
   1) In the enrollment mode, eye scanner shall create an eye template for new personnel and enter the template into system database file created for that person. Template information shall be compatible with system application software.
   2) In the recognition mode, eye scanner shall allow passage when the eye scan data from the verification attempt match an eye template stored in database files.
   3) In the code/credential verification mode, eye scanner shall allow passage when the eye scan data from the verification attempt match the eye scan template associated with the identification code entered into a keypad, or they match the eye scan template associated with credential card data read by a card reader.

i. Reports: Eye scanner shall create and store template match scores for all transactions involving eye retinal scans. Template match scores shall be stored in the matching personnel data file used for report generation.

j. Power: Scanner shall be powered from its associated Controller, requiring not more than 45 W.

k. Enclosure: Eye scanners shall be available with enclosures that are suitable for surface, semiflush, or pedestal mounting. Mounting types shall additionally be suitable for installation in the following locations:
   1) Indoors, controlled environment.
   2) Indoors, uncontrolled environment.

l. Display: LED or other type of visual indicator display shall provide visual and audible status indications and user prompts. Indicate power on/off, and whether user passage requests have been accepted or rejected.

3. Hand Geometry: Use unique human hand measurements to identify authorized, enrolled personnel. The design of this device shall incorporate positive measures to establish that the hand being measured by the device belongs to a living human being.

a. The user's hand shall remain in full view of the user at all times. The scan process of the hand geometry device shall make three-dimensional measurements of the size and shape of the subject's hand. Scanning shall start automatically once the user's hand is properly positioned by the alignment system.

b. Hand geometry device shall be able to use either left or right hand for enrollment and verification.

c. Storage space of each eye template shall not exceed 50 8-bit bytes.

d. Template Update and Acceptance Tolerances: Hand geometry devices shall not automatically update a user's profile. Significant changes in an individual's hand geometry shall require re-enrollment. Hand geometry devices shall provide an adjustable acceptance tolerance or template match criteria under system manager/operator control. Hand geometry device shall determine when multiple attempts are needed for hand geometry verification and shall automatically prompt the user for additional attempts up to a maximum of three. Three failed attempts shall generate an entry-control alarm.

e. Average Verification Time: Hand geometry device shall respond to passage requests by generating an entry request signal to the Controller. The verification time shall be 1.5 seconds or less from the moment hand geometry device initiates the scan process until hand geometry device generates a response signal.

f. Modes: Hand geometry device shall provide an enrollment mode, a recognition mode, and a code/credential verification mode.

1) In the enrollment mode, hand geometry device shall create a hand template for new personnel and enter the template into system database file created for that person. Template information shall be compatible with system application software.
2) In the recognition mode, hand geometry device shall allow passage when the hand scan data from the verification attempt match a hand geometry template stored in database files.
3) In the code/credential verification mode, hand geometry device shall allow passage when the hand scan data from the verification attempt match the hand geometry template associated with the identification code entered into a keypad, or they match the hand geometry template associated with credential card data read by a card reader.

g. Reports: Hand geometry device shall create and store template match scores for all transactions involving hand geometry scans. Template match scores shall be stored in the matching personnel data file used for report generation.
h. Power: Hand geometry device shall be powered from its associated Controller, requiring not more than 45 W.
i. Enclosure: Geometry readers shall be available with enclosures that are suitable for surface, semiflush, or pedestal mounting. Mounting types shall additionally be suitable for installation in the following locations:
1) Indoors, controlled environment.
2) Indoors, uncontrolled environment.
3) Outdoors.
j. Display: LED or other type of visual indicator display shall provide visual and audible status indications and user prompts. Indicate power on/off, and whether user passage requests have been accepted or rejected.

4. Fingerprint Analysis Scanner: Use a unique human fingerprint pattern to identify authorized, enrolled personnel. The design of this device shall incorporate positive measures to establish that the hand or fingers being scanned by the device belong to a living human being.
a. The user's hand shall remain in full view of the user at all times. The scan process of the fingerprint analysis scanner shall perform an optical or other type of scan of the enrollee's fingers. Scanning shall start automatically when the user's fingers are properly positioned.
b. Storage space for each fingerprint template shall not require more than 1250 8-bit bytes.
c. Template Update and Acceptance Tolerances: Fingerprint analysis scanners shall not automatically update a user's profile. Significant changes in an individual's fingerprints shall require re-enrollment. Fingerprint analysis scanners shall provide an adjustable acceptance tolerance or template match criteria under system manager/operator control. Fingerprint analysis scanner shall determine when multiple attempts are needed for fingerprint verification and shall automatically prompt the enrollee for additional attempts up to a maximum of three. Three failed attempts shall generate an entry-control alarm.
d. Average Verification Time: Fingerprint analysis scanner shall respond to passage requests by generating an entry request signal to the Controller. The verification time shall be 2 seconds or less from the moment fingerprint analysis scanner initiates the scan process until fingerprint analysis scanner generates a response signal.
e. Modes: Fingerprint analysis scanner shall provide an enrollment mode, a recognition mode, and a code/credential verification mode.
1) In the enrollment mode, fingerprint analysis scanner shall create a fingerprint template for new personnel and enter the template into the system database file created for that person.
2) In the recognition mode, fingerprint analysis scanner shall allow passage when the fingerprint data from the verification attempt match a fingerprint template stored in database files.
3) In the code/credential verification mode, fingerprint analysis scanner shall allow passage when the fingerprint data from the verification attempt match the fingerprint template associated with the identification code entered into a keypad, or they match the fingerprint template associated with credential card data read by a card reader.

f. Reports: Fingerprint analysis device shall create and store pattern match scores for all transactions involving fingerprint scans. Template match scores shall be stored in the matching personnel data file used for report generation.
g. Power: Fingerprint analysis scanner shall be powered from its associated Controller, requiring not more than 45 W.
h. Enclosure: Scanners shall be available with enclosures that are suitable for surface, semiflush, or pedestal mounting. Mounting types shall additionally be suitable for installation in the following locations:
   1) Indoors, controlled environment.
   2) Indoors, uncontrolled environment.
   3) Outdoors.
i. Display: LED or other type of visual indicator display shall provide visual and audible status indications and user prompts. Indicate power on/off, and whether user passage requests have been accepted or rejected.

5. Iris Scan Device: Use the unique patterns found in the iris of the human eye to identify authorized, enrolled personnel. The device shall use ambient light to capture an image of the iris of a person for identification. The resulting video image shall be compared against a stored template that was captured during the enrollment process. When the presented image is sufficiently similar to the stored image template, then the device shall authenticate the presenting individual as identified. The threshold of similarity shall be adjustable.
   a. Enrollees who wear contact lenses or eyeglasses shall not adversely affect the efficiency and accuracy of the device.
   b. Iris scan device shall provide a means for enrollees to align their eye for identification that does not require facial contact with the device. A manual push-button shall be provided to initiate the scan process when the enrollee's eye is aligned in front of the device.
   c. The device shall include adjustments to accommodate differences in enrollee height.
   d. Template Update: Iris scanners shall not automatically update an enrollee's template. Significant changes in an individual's eye shall require re-enrollment.
   e. Scan acceptance tolerance or template match criteria shall be under system manager/operator control. Iris scanner shall determine when multiple attempts are needed to verify the iris being scanned and shall automatically prompt the enrollee for additional attempts up to three. Three failed attempts shall generate an entry-control alarm.
   f. Average Verification Time: Iris scanner shall respond to passage requests by generating an entry request signal to the Controller. The verification time shall be 1.5 seconds or less from the moment iris scanner initiates the scan process until iris scanner generates a response signal.
   g. Modes: Iris scanner shall provide an enrollment mode, a recognition mode, and a code/credential verification mode.
      1) In the enrollment mode, iris scanner shall create an iris template for new personnel and enter the template into system database file created for that person. Template information shall be compatible with system application software.
      2) In the recognition mode, iris scanner shall allow passage when the iris scan data from the verification attempt match an iris template stored in database files.
      3) In the code/credential verification mode, iris scanner shall allow passage when the iris scan data from the verification attempt match the iris scan template associated with the identification code entered into a keypad, or they match the iris scan template associated with credential card data read by a card reader.
   h. Reports: Iris imaging shall create and store template match scores for all transactions involving iris scans. Template match scores shall be stored in the matching personnel data file used for report generation.
   i. Power: Iris scanner shall be powered from its associated Controller, requiring not more than 45 W.
   j. Enclosure: Eye scanners shall be available with enclosures that are suitable for surface, semiflush, or pedestal mounting. Mounting types shall additionally be suitable for installation in the following locations:
      1) Indoors, controlled environment.

2) Indoors, uncontrolled environment.

k. Display: LED or other type of visual indicator display shall provide visual and audible status indications and user prompts. Indicate power on/off, and whether user passage requests have been accepted or rejected.

N. Enrollment Center

1. Equipment for enrolling personnel into, and removing personnel from, system database, using a dedicated workstation PC **OR** central-station equipment, **as directed**.
   a. Include equipment to enroll selected biometric credentials.
2. Enrollment equipment shall support encoding of credential cards including cryptographic and other internal security checks as required for system.
   a. Allow only authorized entry-control enrollment personnel to access the enrollment equipment using passwords.
   b. Include enrollment subsystem configuration controls and electronic diagnostic aids for subsystem setup and troubleshooting with the Central Station.
   c. Enrollment station records printer shall meet requirements of the report printer.
3. Entry-Control Enrollment Software:
   a. Shall include database management functions for the system, and shall allow an operator to change and modify the data entered in the system as needed.
   b. Software shall not have alarm response or acknowledgment functions as a programmable function.
   c. Multiple, password-protected access levels shall be provided at the enrollment station.
   d. Database management and modification functions shall require a higher operator-access level than personnel enrollment functions.
   e. Software shall provide a means for disabling the enrollment station when it is unattended, to prevent unauthorized use.
   f. Software shall provide a method to enter personnel identifying information into the entry-control database files through enrollment stations to include a credential unit in use at the installation.
   g. In the case of personnel identity-verification subsystems, this data shall include biometric data.
   h. Software shall allow entry of this data into the system database files through the use of simple menu selections and data fields. The data field names shall be customized to suit user and site needs.
   i. Personnel identity-verification subsystems selected for use with the system shall fully support the enrollment function and shall be compatible with the entry-control database files.
4. Accessories:
   a. Steel desk-type console, swivel chair on casters, and equipment racks.
   b. Console and Equipment Racks: Comply with EIA-310-D.
   c. Equipment, with the exception of the printers, shall be rack mounted in the console and equipment racks.
   d. Storage Cabinet: Locking cabinet approximately 72 inches (1830 mm) high, 36 inches (915 mm) wide, and 24 inches (610 mm) deep, with 3 adjustable shelves and 2 storage racks for storage of disks, tapes, printouts, printer paper, ribbons, manuals, and other documentation.
5. System Capacity: Number of badges shall be limited only by hard disk space. Badge templates and images shall be in color, supporting the maximum color capability of Microsoft Windows operating system.
6. Badge Configuration:
   a. Software for badge template creation shall include a template consisting of background and predetermined locations of photographs, text objects and data fields for text, and bar-code and biometric information. Include automatic sizing of data fields placed on a badge to compensate for names, which may otherwise be too large to fit in the area designated.
   b. Allow different badge templates to be used for each department, tenant, or visitor.

c. As a setup option, templates shall be automatically selected for the badge, based on the group the credential holder is assigned to. Allow the operator to override the automatic template selection and use a template chosen by the operator for creating a badge.
d. Setup shall determine which graphics and credential holder information will be displayed and where on the card it will be placed. All data in the security access system such as name, code, group, access level, and any of the 99 user-defined fields shall be selectable, with the ability to place them anywhere on the card.
e. System shall include an importing, filing, and recall system of stored images and shapes that can be placed on the badge.
f. Allow multiple images on same badge, including, but not be limited to, bar codes, digital photos, and signatures.
g. Support transparent backgrounds so that image is only surrounded by the intended background, but not its immediate background.

7. Photo Imaging: Integral to security access.
a. Import images from bitmap file formats, digital cameras, TWAIN cameras, or scanners. Allow image cropping and editing, WYSIWYG badge building application, and badge print preview and printing capabilities.
b. System shall support multiple images stored for each credential holder, including signatures, portrait views, and profile views.

8. Text Objects: Badge configuration shall provide for creation of custom text as an object, allowing font selection, typing, scaling, and formatting of the text object. Formatting options shall include changing font, font size, text flow, and text alignment; bending or curving the text object into a circle or semicircle; applying 3-D effects; and applying predefined effects such as tilt, extrusion, or beveling. Text shall be placed and optionally automatically centered within any region of the badge layout.

9. Badges and Credential Cards:
a. Badges are credential cards that do not contain data to be read by card readers.
b. Credential cards shall store uniquely coded data used by card readers as an Identifier.
1) Magnetic-Stripe Cards: Comply with ISO 7810, ISO 7811-1, ISO 7811-2, ISO 7811-3, and ISO 7811-6. Use single-layer magnetic tape material that is coated with a plastic slick protective coat and affixed to the back of the credential card near the top.
2) Wiegand Wire Effect Cards: Ferromagnetic wires laminated into the credential card using binary digits specified for Wiegand readers to generate a unique credential card identification code.
3) Proximity Cards **OR** Key Fobs, **as directed**: Use proximity detection without physical contact with the proximity reader for proper operation.
c. Allow entry-control card to be modified by lamination or direct print process during the enrollment process for use as a picture and identification badge without reduction of readability. The design shall allow for the addition of at least one slot or hole to accommodate the attachment of a clip for affixing the credential card to the type of badge holder used at the site.
1) Card Size and Dimensional Stability: Standard size, 2-1/8 by 3-3/8 inches (54 by 85 mm); dimensionally stable so that an undamaged card with deformations resulting from normal use is readable by the card reader.
2) Card Material: Abrasion resistant, nonflammable, and nontoxic; and impervious to solar radiation and effects of ultraviolet light.
3) Card Construction: Core and laminate or monolithic construction. Lettering, logos, and other markings shall be hot stamped into the credential material or direct printed.
a) With holographic images **OR** phosphorous ink, **as directed**, as a security enhancement.
b) Furnish equipment for on-site assembly and lamination of credential cards.
4) Card Durability and Maintainability: Designed and constructed to yield a useful lifetime of at least 5 years or 5000 insertions or swipes, whichever results in a longer

period of time. Allow credential cards to be cleaned by wiping with a sponge or cloth wetted with soap and water.

10. Card-Making Equipment: Consisting of a workstation, video camera, video-imaging equipment, and a printer.
    a. Camera: NTSC color standard, RGB video output, 470 lines minimum horizontal resolution, and automatic white balance with full rated output under illumination of 0.5 fc (5 lx).
    b. Video Imaging: Live-image capture software and hardware and a digital signature capture pad.
    c. Standard workstation, modified as follows:
        1) Redundant workstation is not required.
        2) Printer is not required.
        3) UPS is not required.
        4) Sound card is not required.
    d. Printer: Dye-sublimation resin thermal transfer, 300 dpi resolution, 16.7 million colors, accepting cards ranging in size from 2.1 by 3 inches to 2.6 by 3.7 inches (53 by 76 mm to 66 by 94 mm) and having card thickness ranging from 0.020 to 0.060 inch (0.5 to 1.5 mm). Printer shall have options for encoding magnetic stripe using tracks 1, 2, and 3. Throughput shall be not less than 60 seconds per card.

O. Push-Button Switches
1. Push-Button Switches: Momentary-contact back-lighted push buttons, with stainless-steel switch enclosures.
    a. Electrical Ratings:
        1) Minimum continuous current rating of 10 A at 120 V ac or 5 A at 240-V ac.
        2) Contacts that will make 720 VA at 60 A and that will break at 720 VA at 10 A.
    b. Enclosures: Flush or surface mounting. Push buttons shall be suitable for flush mounting in the switch enclosures.
    c. Enclosures shall additionally be suitable for installation in the following locations:
        1) Indoors, controlled environment.
        2) Indoors, uncontrolled environment.
        3) Outdoors.
    d. Power: Push-button switches shall be powered from their associated Controller, using dc control.

P. Door And Gate Hardware Interface
1. Exit Device with Alarm: Operation of the exit device shall generate an alarm and annunciate a local alarm. Exit device and alarm contacts are specified in Division 08 Section "Door Hardware".
2. Exit Alarm: Operation of a monitored door shall generate an alarm. Exit devices and alarm contacts are specified in Division 08 Section "Door Hardware".
3. Electric Door Strikes: Use end-of-line resistors to provide power line supervision. Signal switches shall transmit data to Controller to indicate when the bolt is not engaged and the strike mechanism is unlocked, and shall report a forced entry. Power and signal shall be from the Controller. Electric strikes are specified in Division 08 Section "Door Hardware".
4. Electromagnetic Locks: End-of-line resistors shall provide power line supervision. Lock status sensing signal shall positively indicate door is secure. Power and signal shall be from the Controller. Electromagnetic locks are specified in Division 08 Section "Door Hardware".
5. Vehicle Gate Operator: Interface electrical operation of gate with controls of this Section. Vehicle gate operators shall be connected, monitored, and controlled, by the security access Controllers. Vehicle gate and accessories are specified in Division 32 Section "Chain Link Fences And Gates".

Q. Field-Processing Software
1. Operating System:

a. Local processors shall contain an operating system that controls and schedules that local processor's activities in real time.
b. Local processor shall maintain a point database in its memory that includes parameters, constraints, and the latest value or status of all points connected to that local processor.
c. Execution of local processor application programs shall utilize the data in memory resident files.
d. Operating system shall include a real-time clock function that maintains the seconds, minutes, hours, date, and month, including day of the week.
e. Local processor real-time clock shall be automatically synchronized with the central station at least once per day to plus or minus 10 seconds (the time synchronization shall be accomplished automatically, without operator action and without requiring system shutdown).

2. Startup Software:
a. Causes automatic commencement of operation without human intervention, including startup of all connected I/O functions.
b. Local processor restart program based on detection of power failure at the local processor shall be included in the local processor software.
c. Initiates operation of self-test diagnostic routines.
d. Upon failure of the local processor, if the database and application software are no longer resident, the local processor shall not restart and systems shall remain in the failure mode indicated until the necessary repairs are made.
e. If the database and application programs are resident, the local processor shall immediately resume operation.

3. Operating Mode:
a. Local processors shall control and monitor inputs and outputs as specified, independent of communications with the central station or designated workstations.
b. Alarms, status changes, and other data shall be transmitted to the central station or designated workstations when communications circuits are operable.
c. If communications are not available, each local processor shall function in a stand-alone mode and operational data, including the status and alarm data normally transmitted to the central station or designated workstations, shall be stored for later transmission to the central station or designated workstations.
d. Storage for the latest 4000 events shall be provided at local processors, as a minimum.
e. Local processors shall accept software downloaded from the central station.
f. Panel shall support flash ROM technology to accomplish firmware downloads from a central location.

4. Failure Mode: Upon failure for any reason, each local processor shall perform an orderly shutdown and force all local processor outputs to a predetermined (failure-mode) state, consistent with the failure modes shown and the associated control device.

5. Functions:
a. Monitoring of inputs.
b. Control of outputs.
c. Reporting of alarms automatically to the central station.
d. Reporting of sensor and output status to central station upon request.
e. Maintenance of real time, automatically updated by the central station at least once a day.
f. Communication with the central station.
g. Execution of local processor resident programs.
h. Diagnostics.
i. Download and upload data to and from the central station.

R. Field-Processing Hardware
1. Alarm Annunciation Local Processor:
a. Respond to interrogations from the field device network, recognize and store alarm status inputs until they are transmitted to the central station, and change outputs based on commands received from the central station.

b. Local processor shall also automatically restore communication within 10 seconds after an interruption with the field device network and provide dc line supervision on each of its alarm inputs.
c. Local processor inputs shall monitor dry contacts for changes of state that reflect alarm conditions.
d. Local processor shall have at least eight alarm inputs which allow wiring contacts as normally open or normally closed for alarm conditions; and shall provide line supervision for each input by monitoring each input for abnormal open, grounded, or shorted conditions using dc current change measurements.
e. Local processor shall report line supervision alarms to the central station.
f. Alarms shall be reported for any condition that remains abnormal at an input for longer than 500 milliseconds.
g. Alarm condition shall be transmitted to the central computer during the next interrogation cycle.
h. Local processor outputs shall reflect the state of commands issued by the central station.
i. Outputs shall be a form C contact and shall include normally open and normally closed contacts.
j. Local processor shall have at least four command outputs.
k. Local processor shall be able to communicate with the central station via RS-485 or TCP/IP as a minimum.

2. Processor Power Supply:
   a. Local processor and sensors shall be powered from an uninterruptible power source.
   b. Uninterruptible power source shall provide eight hours of battery back-up power in the event of primary power failure and shall automatically fully recharge the batteries within 12 hours after primary power is restored.
   c. If the facility is without an emergency generator, the uninterruptible power source shall provide 24 hours of battery backup power.
   d. There shall be no equipment malfunctions or perturbations or loss of data during the switch from primary to battery power and vice versa.
   e. Batteries shall be sealed, non-outgassing type.
   f. Power supply shall be equipped with an indicator for ac input power and an indicator for dc output power.
   g. Loss of primary power shall be reported to the central station as an alarm.
3. Auxiliary Equipment Power: A GFI service outlet shall be furnished inside the local processor's enclosure.
4. Entry-Control Local Processor:
   a. Entry-control local processor shall respond to interrogations from the field device network, recognize and store alarm status inputs until they are transmitted to the central station, and change outputs based on commands received from the central station.
   b. Local processor shall also automatically restore communication within 10 seconds after an interruption with the field device network and provide dc line supervision on each of its alarm inputs.
   c. Entry-control local processor shall provide local entry-control functions including communicating with field devices such as card readers, keypads, biometric personnel identity-verification devices, door strikes, magnetic latches, gate and door operators, and exit push buttons.
   d. Processor shall also accept data from entry-control field devices as well as database downloads and updates from the central station that include enrollment and privilege information.
   e. Processor shall send indications of successful or failed attempts to use entry-control field devices and shall make comparisons of presented information with stored identification information.
   f. Processor shall grant or deny entry by sending control signals to portal-control devices and mask intrusion-alarm annunciation from sensors stimulated by authorized entries.

g. Entry-control local processor shall use inputs from entry-control devices to change modes between access and secure.
h. Local processor shall maintain a date-time- and location-stamped record of each transaction and transmit transaction records to the central station.
i. Processor shall operate as a stand-alone portal controller using the downloaded database during periods of communication loss between the local processor and the central station.
j. Processor shall store a minimum of 4000 transactions during periods of communication loss between the local processor and the central station for subsequent upload to the central station upon restoration of communication.
k. Local processor inputs shall monitor dry contacts for changes of state that reflect alarm conditions.
l. Local processor shall have at least eight alarm inputs which allow wiring contacts as normally open or normally closed for alarm conditions, and shall also provide line supervision for each input by monitoring each input for abnormal open, grounded, or shorted conditions using dc current change measurements.
m. Local processor shall report line supervision alarms to the central station.
n. Alarms shall be reported for any condition that remains abnormal at an input for longer than 500 ms.
o. Alarm condition shall be transmitted to the central station during the next interrogation cycle.
p. Entry-control local processor shall include the necessary software drivers to communicate with entry-control field devices. Information generated by the entry-control field devices shall be accepted by the local processor and automatically processed to determine valid identification of the individual present at the portal.
q. Upon authentication of the credentials or information presented, the local processor shall automatically check privileges of the identified individual, allowing only those actions granted as privileges.
r. Privileges shall include, but are not limited to, time of day control, day of week control, group control, and visitor escort control. The local processor shall maintain a date-time- and location-stamped record of each transaction.
s. Transaction is defined as any successful or unsuccessful attempt to gain access through a controlled portal by the presentation of credentials or other identifying information.
t. Local processor outputs shall reflect the state of commands issued by the central station.
u. Outputs shall be a form C contact and shall include normally open and normally closed contacts.
v. Local processor shall have at least four addressable outputs.
w. The entry-control local processor shall also provide control outputs to portal-control devices.
x. Local processor shall be able to communicate with the central station via RS-485 or TCP/IP as a minimum.
y. The system manufacturer shall provide strategies for downloading database information for panel configurations and cardholder data to minimize the required download time when using IP connectivity.

S. Tia 232-F Ascii Interface Specifications
1. ASCII interface shall allow TIA 232-F connections to be made between the control station operating as the host PC and any equipment that will accept TIA 232-F ASCII command strings, such as CCTV switches, intercoms, and paging systems.
a. Alarm inputs in system shall allow for individual programming to output up to four unique ASCII character strings through two different COM ports on the host PC.
b. Inputs shall have the ability to be defined to transmit a unique ASCII string for alarm and one for restore through one COM port, and a unique ASCII string for a nonalarm, abnormal condition and one for a normal condition through the same or different COM port.
c. Predefined ASCII character strings shall have the ability to be up to 420 characters long with full use of all the ASCII control characters, such as return or line feed. Character

strings shall be defined in the system database and then assigned to the appropriate inputs.

d. COM ports of the host PC used to interface with external equipment shall be defined in the setup portion of the software. COM port's baud rate, word length, stop bits, and parity shall be definable in the software to match that of the external equipment.

2. Pager-System Interface: Alarms shall be able to activate a pager system with customized message for each input alarm.
   a. TIA 232-F output shall be capable of connection to a pager interface that can be used to call a paging system or service and send a signal to a portable pager. System shall allow an individual alphanumeric message per alarm input to be sent to the paging system. This interface shall support both numeric and alphanumeric pagers.
3. Alarm-System Interface:
   a. TIA 232-F output shall be capable of transmitting alarms from other monitoring and alarm systems to central-station automation software.
   b. Alternatively, alarms that are received by this access-control system are to be transferred to the alarm automation system as if they were sent through a digital alarm receiver.
      1) System shall be able to transmit an individual message from any alarm input to a burglar-alarm automation monitoring system.
      2) System shall be able to append to each message a predefined set of character strings as a prefix and a suffix.

T. Floor Select Elevator Control
1. Elevator access control shall be integral to security access.
   a. System shall be capable of providing full elevator security and control through dedicated Controllers without relying on the control-station host PC for elevator control decisions.
   b. Access-control system shall enable and disable car calls on each floor and floor select buttons in each elevator car, restricting passengers' access to the floors where they have been given access.
   c. System setup shall, through programming, automatically secure and unsecure each floor select button of a car individually by time and day. Each floor select button within a car shall be separately controlled so that some floors may be secure while others remain unsecure.
   d. When a floor select button is secure, it shall require the passenger to use his/her access code and have access to that floor before the floor select button will operate. The passenger's credential shall determine which car call and floor select buttons are to be enabled, restricting access to floors unless authorized by system's access code database. Floor select button shall be enabled only in the car where the credential holder is the passenger.
2. Security access system shall record which call button is pressed, along with credential and time information.
   a. System Controller shall record elevator access data.
   b. The Controller shall reset all additional call buttons that may have been enabled by the user's credential.
   c. The floor select elevator control shall allow for manual override either individually by floor or by cab as a group from a workstation PC.

U. Real-Time Guard Tour
1. Guard tour module shall provide the ability to plan, track, and route tours. Module shall input an alarm during tour if guard fails to make a station. Tours can be programmed for sequential or random tour-station order.
   a. Guard tour setup shall define specific routes or tours for the guard to take, with time restrictions in which to reach every predefined tour station.
   b. Guard tour activity shall be automatically logged to the central-station PC's hard drive.
   c. If the guard is early or late to a tour station, a unique alarm per station shall appear at the Central Station to indicate the time and station.

d. Guard tour setup shall allow the tours to be executed sequentially or in a random order with an overall time limit set for the entire tour instead of individual times for each tour station.
e. Setup shall allow recording of predefined responses that will display for the operator at the control station should a "Failed to Check-in" alarm occur.

2. Guard tour module shall allow proprietary direct-connected systems to use security access-control hardware to perform guard tour management in real time.
3. A tour station is a physical location a guard shall reach and perform an action indicating that the guard has arrived. This action, performed at the tour station, shall be 1 of 13 different events with any combination of station types within the same tour. A tour station shall be one of the following event types:
   a. Access Granted.
   b. Access Denied Code.
   c. Access Denied Card plus PIN.
   d. Access Denied Time Zone.
   e. Access Denied Level.
   f. Access Denied Facility.
   g. Access Denied Code Timer.
   h. Access Denied Anti-Passback.
   i. Access Granted Passback Violation.
   j. Alarm.
   k. Restored.
   l. Input Normal.
   m. Input Abnormal.
4. Guard tour and other system features shall operate simultaneously with no interference.
5. Guard Tour Module Capacity: 999 possible guard tour definitions with each tour having up to 99 tour stations. System shall allow all 999 tours to be running at same time.

V. Video And Camera Control
1. Control station or designated workstation displays live video from a CCTV source.
   a. Control Buttons: On the display window, with separate control buttons to represent Left, Right, Up, Down, Zoom In, Zoom Out, Scan, and a minimum of two custom command auxiliary controls.
   b. Provide at least seven icons to represent different types of cameras, with ability to import custom icons. Provide option for display of icons on graphic maps to represent their physical location.
   c. Provide the alarm-handling window with a command button that will display the camera associated with the alarm point.
2. Display mouse-selectable icons representing each camera source, to select source to be displayed. For CCTV sources that are connected to a video switcher, control station shall automatically send control commands through a COM port to display the requested camera when the camera icon is selected.
3. Allow cameras with preset positioning to be defined by displaying a different icon for each of the presets. Provide control with Next and Previous buttons to allow operator to cycle quickly through the preset positions.

W. Cables
1. General Cable Requirements: Comply with requirements in Division 28 Section "Conductors And Cables For Electronic Safety And Security" and as recommended by system manufacturer for integration requirement.
2. PVC-Jacketed, TIA 232-F Cables:
   a. Two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, and individual aluminum-foil/polyester-tape shielded pairs with 100 percent shield coverage; PVC jacket.
   b. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.

c. NFPA 70, Type CM.
d. Flame Resistance: UL 1581 vertical tray.

3. Plenum-Type, TIA 232-F Cables:
   a. Two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum-foil/polyester-tape shielded pairs with 100 percent shield coverage; plastic jacket.
   b. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
   c. NFPA 70, Type CMP.
   d. Flame Resistance: NFPA 262 flame test.
4. PVC-Jacketed, TIA 485-A Cables: Two pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, PVC insulation, unshielded, PVC jacket, and NFPA 70, Type CMG.
5. Plenum-Type, TIA 485-A Cables:
   a. Two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and fluorinated-ethylene-propylene jacket.
   b. NFPA 70, Type CMP.
   c. Flame Resistance: NFPA 262 flame test.
6. Multiconductor, PVC Readers and Wiegand Keypads Cables:
   a. No. 22 AWG, paired and twisted multiple conductors, stranded (7x30) tinned copper conductors, semirigid PVC insulation, overall aluminum foil-polyester tape shield with 100 percent shield coverage, plus tinned copper braid shield with 65 percent shield coverage, and PVC jacket.
   b. NFPA 70, Type CMG.
   c. Flame Resistance: UL 1581 Vertical Tray.
   d. For TIA 232-F applications.
7. Paired PVC Readers and Wiegand Keypad Cables:
   a. Three pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, individual aluminum foil-polyester tape shielded pairs each with No. 22 AWG, stranded tinned copper drain wire, 100 percent shield coverage, and PVC jacket.
   b. NFPA 70, Type CM.
   c. Flame Resistance: UL 1581 Vertical Tray.
8. Paired PVC Readers and Wiegand Keypads Cable:
   a. Three 3 pairs, twisted, No. 20 AWG, stranded (7x28) tinned copper conductors, polyethylene (polyolefin) insulation, individual aluminum foil-polyester tape shielded pairs each with No. 22 AWG, stranded (19x34) tinned copper drain wire, 100 percent shield coverage, and PVC jacket.
   b. NFPA 70, Type CM.
   c. Flame Resistance: UL 1581 Vertical Tray.
9. Paired, Plenum-Type, Reader and Wiegand Keypad Cable:
   a. Three pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, individual aluminum foil-polypropylene tape shielded pairs each with No. 22 AWG, stranded tinned copper drain wire, 100 percent shield coverage, and fluorinated-ethylene-propylene jacket.
   b. NFPA 70, Type CMP.
   c. Flame Resistance: NFPA 262 Flame Test.
10. Multiconductor, Plenum-Type, Reader and Wiegand Keypad Cable:
    a. Six conductors, No. 20 AWG, stranded (7x28) tinned copper conductors, fluorinated-ethylene-propylene insulation, overall aluminum foil-polyester tape shield with 100 percent shield coverage plus tinned copper braid shield with 85 percent shield coverage, and fluorinated-ethylene-propylene jacket.
    b. NFPA 70, Type CMP.
    c. Flame Resistance: NFPA 262 Flame Test.
11. Paired Lock Cable:

a. One pair, twisted, No. 16 AWG, stranded (19x29) tinned copper conductors, PVC insulation, unshielded, and PVC jacket.
b. NFPA 70, Type CMG.
c. Flame Resistance: UL 1581 Vertical Tray.

12. Paired, Plenum-Type, Lock Cable:
    a. One pair, twisted, No. 16 AWG, stranded (19x29) tinned copper conductors, PVC insulation, unshielded, and PVC jacket.
    b. NFPA 70, Type CMP.
    c. Flame Resistance: NFPA 262 Flame Test.
13. Paired Lock Cable:
    a. One pair, twisted, No. 18 AWG, stranded (19x30) tinned copper conductors, PVC insulation, unshielded, and PVC jacket.
    b. NFPA 70, Type CMG.
    c. Flame Resistance: UL 1581 Vertical Tray.
14. Paired, Plenum-Type, Lock Cable:
    a. One pair, twisted, No. 18 AWG, stranded (19x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and plastic jacket.
    b. NFPA 70, Type CMP.
    c. Flame Resistance: NFPA 262 Flame Test.
15. Paired Input Cable:
    a. One pair, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, overall aluminum foil-polyester tape shield with No. 22 AWG, stranded (7x30) tinned copper drain wire, 100 percent shield coverage, and PVC jacket.
    b. NFPA 70, Type CMR.
    c. Flame Resistance: UL 1666 Riser Flame Test.
16. Paired, Plenum-Type, Input Cable:
    a. One pair, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, aluminum foil-polyester tape shield (foil side out), with No. 22 AWG drain wire, 100 percent shield coverage, and plastic jacket.
    b. NFPA 70, Type CMP.
    c. Flame Resistance: NFPA 262 Flame Test.
17. Paired AC Transformer Cable:
    a. One pair, twisted, No. 18 AWG, stranded (7x26) tinned copper conductors, PVC insulation, unshielded, and PVC jacket.
    b. NFPA 70, Type CMG.
18. Paired, Plenum-Type, AC Transformer Cable:
    a. One pair, twisted, No. 18 AWG, stranded (19x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and plastic jacket.
    b. NFPA 70, Type CMP.
    c. Flame Resistance: NFPA 262 Flame Test.
19. Elevator Travel Cable:
    a. Steel center core, with shielded, twisted pairs, No. 20 AWG conductor size.
    b. Steel center support shall be preformed, flexible, low-torsion, zinc-coated, steel wire rope; insulated with 60 deg C flame-resistant PVC and covered with a nylon or cotton braid.
    c. Shielded Pairs: Insulated copper conductors; color-coded, insulated with 60 deg C flame-resistant PVC; each pair shielded with bare copper braid for 85 percent coverage.
    d. Electrical grade, dry jute filler
    e. Helically wound synthetic fiber binder
    f. Rayon or cotton braid applied with 95 percent coverage.
    g. 60 deg C PVC jacket specifically compounded for flexibility and abrasion resistance and complying with UL VW-1 and CSA FT1 flame rated.
20. LAN Cabling:
    a. Comply with requirements in Division 28 Section "Conductors And Cables For Electronic Safety And Security".
    b. NFPA 262.

X. Transformers: NFPA 70, Class II control transformers, NRTL listed. Transformers for security access-control system shall not be shared with any other system.

Y. Cable And Asset Management Software
1. Computer-based cable and asset management system, with fully integrated database and graphic capabilities, complying with requirements in TIA/EIA-606.
   a. Document physical characteristics by recording the network, asset, user, TIA/EAI details, device configurations, and exact connections between equipment and cabling.
      1) Manage the physical layer of security system.
      2) List device configurations.
      3) List and display circuit connections.
      4) Record firestopping data.
      5) Record grounding and bonding connections and test data.
   b. Information shall be presented in database view, schematic plans, or technical drawings.
      1) Microsoft Visio Technical Drawing shall be used as drawing and schematic plans software. Drawing symbols, system layout, and design shall comply with SIA/IAPSC AG-01.
   c. System shall interface with the following testing and recording devices:
      1) Direct upload tests from circuit testing instrument into the PC.
      2) Direct download circuit labeling into labeling printer.
2. Software shall be designed for Microsoft Windows of same version as security access system's Central Station and workstations and shall be installed on the designated PC, using a hard drive dedicated only to this management function. Hard-drive capacity shall be not less than 50 GB.

1.3 EXECUTION

A. Examination
1. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
2. Examine roughing-in for LAN and control cable conduit systems to PCs, controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation
1. Comply with recommendations in SIA CP-01.
2. Comply with TIA/EIA 606-A, "Administration Standard for Commercial Telecommunications Infrastructure."
3. Obtain detailed Project planning forms from manufacturer of access-control system; develop custom forms to suit Project. Fill in all data available from Project plans and specifications and publish as Project planning documents for review and approval.
   a. Record setup data for control station and workstations.
   b. For each Location, record setup of controller features and access requirements.
   c. Propose start and stop times for time zones and holidays, and match up access levels for doors.
   d. Set up groups, facility codes, linking, and list inputs and outputs for each controller.
   e. Assign action message names and compose messages.
   f. Set up alarms. Establish interlocks between alarms, intruder detection, and video surveillance features.
   g. Prepare and install alarm graphic maps.
   h. Develop user-defined fields.
   i. Develop screen layout formats.
   j. Propose setups for guard tours and key control.

k. Discuss badge layout options; design badges.
l. Complete system diagnostics and operation verification.
m. Prepare a specific plan for system testing, startup, and demonstration.
n. Develop acceptance test concept and, on approval, develop specifics of the test.

4. Develop cable and asset-management system details; input data from construction documents. Include system schematics and Visio Technical Drawings in electronic format.
5. In meetings with the Owner, present Project planning documents and review, adjust, and prepare final setup documents. Use final documents to set up system software.

C. Cabling
1. Comply with NECA 1, "Good Workmanship in Electrical Contracting."
2. Install cables and wiring according to requirements in Division 28 Section "Conductors And Cables For Electronic Safety And Security".
3. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.
4. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use NRTL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.
5. Install LAN cables using techniques, practices, and methods that are consistent with Category 5E rating of components and fiber-optic rating of components, and that ensure Category 6 performance and fiber-optic performance of completed and linked signal paths, end to end.
6. Boxes and enclosures containing security system components or cabling, and which are easily accessible to employees or to the public, shall be provided with a lock. Boxes above ceiling level in occupied areas of the building shall not be considered to be accessible. Junction boxes and small device enclosures below ceiling level and easily accessible to employees or the public shall be covered with a suitable cover plate and secured with tamperproof screws.
7. Install end-of-line resistors at the field device location and not at the Controller or panel location.

D. Cable Application
1. Comply with TIA-569-B, "Commercial Building Standard for Telecommunications Pathways and Spaces."
2. Cable application requirements are minimum requirements and shall be exceeded if recommended or required by manufacturer of system hardware.
3. TIA 232-F Cabling: Install at a maximum distance of 50 feet (15 m).
4. TIA 485-A Cabling: Install at a maximum distance of 4000 feet (1220 m).
5. Card Readers and Keypads:
a. Install number of conductor pairs recommended by manufacturer for the functions specified.
b. Unless manufacturer recommends larger conductors, install No. 22 AWG wire if maximum distance from Controller to the reader is 250 feet (75 m), and install No. 20 AWG wire if maximum distance is 500 feet (150 m).
c. For greater distances, install "extender" or "repeater" modules recommended by manufacturer of the Controller.
d. Install minimum No. 18 AWG shielded cable to readers and keypads that draw 50 mA or more.
6. Install minimum No. 16 AWG cable from Controller to electrically powered locks. Do not exceed 250 feet (75 m) **OR** 500 feet (150 m), **as directed**.
7. Install minimum No. 18 AWG ac power wire from transformer to Controller, with a maximum distance of 25 feet (8 m).

E. Grounding
1. Comply with Division 26 Section "Grounding And Bonding For Electrical Systems".
2. Comply with IEEE 1100, "Recommended Practice for Power and Grounding Electronic Equipment."

3. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
4. Bond shields and drain conductors to ground at only one point in each circuit.
5. Signal Ground:
   a. Terminal: Locate in each equipment room and wiring closet; isolate from power system and equipment grounding.
   b. Bus: Mount on wall of main equipment room with standoff insulators.
   c. Backbone Cable: Extend from signal ground bus to signal ground terminal in each equipment room and wiring closet.

F. Installation
1. Push Buttons: Where multiple push buttons are housed within a single switch enclosure, they shall be stacked vertically with each push-button switch labeled with 1/4-inch- (6.4-mm-) high text and symbols as required. Push-button switches shall be connected to the Controller associated with the portal to which they are applied, and shall operate the appropriate electric strike, electric bolt, or other facility release device.
2. Install card readers, keypads, push buttons, and biometric readers.

G. Identification
1. In addition to requirements in this Article, comply with applicable requirements in Division 26 Section "Identification For Electrical Systems" and with TIA/EIA-606.
2. Using software specified in "Cable and Asset Management Software" Article, develop cable administration drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable, and label cable and jacks, connectors, and terminals to which it connects with the same designation. Use logical and systematic designations for facility's architectural arrangement.
3. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
   a. All wiring conductors connected to terminal strips shall be individually numbered, and each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with the name and number of the particular device as shown.
   b. Each wire connected to building-mounted devices is not required to be numbered at the device if the color of the wire is consistent with the associated wire connected and numbered within the panel or cabinet.
4. At completion, cable and asset management software shall reflect as-built conditions.

H. System Software and Hardware
1. Develop, install, and test software and hardware, and perform database test for the complete and proper operation of systems involved. Assign software license to the Owner.

I. Field Quality Control
1. Perform tests and inspections.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist testing.
2. Testing and Inspections:
   a. LAN Cable Procedures: Inspect for physical damage and test each conductor signal path for continuity and shorts. Use Class 2, bidirectional, Category 5 tester. Test for faulty connectors, splices, and terminations. Test according to TIA/EIA-568-B.1, "Commercial Building Telecommunications Cabling Standards - Part 1 General Requirements." Link performance for UTP cables must comply with minimum criteria in TIA/EIA-568-B.
   b. Test each circuit and component of each system. Tests shall include, but are not limited to, measurements of power supply output under maximum load, signal loop resistance, and leakage to ground where applicable. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of the calculated battery

operating time. Provide special equipment and software if testing requires special or dedicated equipment.

c. Operational Test: After installation of cables and connectors, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.

3. Devices and circuits will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

J. Startup Service
1. Engage a factory-authorized service representative to supervise and assist with startup service.
a. Complete installation and startup checks according to approved procedures that were developed in "Preparation" Article and with manufacturer's written instructions.
b. Enroll and prepare badges and access cards for Owner's operators, management, and security personnel.

K. Protection
1. Maintain strict security during the installation of equipment and software. Rooms housing the control station, and workstations that have been powered up shall be locked and secured, with an activated burglar alarm and access-control system reporting to a Central Station complying with UL 1610, "Central-Station Burglar-Alarm Units," during periods when a qualified operator in the employ of Contractor is not present.

END OF SECTION 28 16 11 00b

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Task	Specification	Specification Description
28 16 11 00	27 51 43 00	Educational Intercommunications and Program Systems
28 16 11 00	26 33 43 00b	Public Address and Mass Notification Systems

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SECTION 28 21 31 00 - VIDEO SURVEILLANCE

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for video surveillance. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes a video surveillance system consisting of cameras, digital video recorder, data transmission wiring, and a control station with its associated equipment.
2. Video surveillance system shall be integrated with monitoring and control system specified in Division 13 Section "Perimeter Security", "Intrusion Detection", "Security Access", and PLC Electronic Detention Monitoring and Control Systems", which specifies systems integration.

C. Definitions
1. AGC: Automatic gain control.
2. BNC: Bayonet Neill-Concelman - type of connector.
3. B/W: Black and white.
4. CCD: Charge-coupled device.
5. FTP: File transfer protocol.
6. IP: Internet protocol.
7. LAN: Local area network.
8. MPEG: Moving picture experts group.
9. NTSC: National Television System Committee.
10. PC: Personal computer.
11. PTZ: Pan-tilt-zoom.
12. RAID: Redundant array of independent disks.
13. TCP: Transmission control protocol - connects hosts on the Internet.
14. UPS: Uninterruptible power supply.
15. WAN: Wide area network.

D. Performance Requirements
1. Seismic Performance: Video surveillance system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals
1. Product Data: For each type of product indicated. Include dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
2. Shop Drawings: For video surveillance. Include plans, elevations, sections, details, and attachments to other work.
a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
b. Functional Block Diagram: Show single-line interconnections between components for signal transmission and control. Show cable types and sizes.
c. Dimensioned plan and elevations of equipment racks, control panels, and consoles. Show access and workspace requirements.
d. UPS: Sizing calculations.
e. Wiring Diagrams: For power, signal, and control wiring.

3. Equipment List: Include every piece of equipment by model number, manufacturer, serial number, location, and date of original installation. Add pretesting record of each piece of equipment, listing name of person testing, date of test, set points of adjustments, name and description of the view of preset positions, description of alarms, and description of unit output responses to an alarm.
4. Seismic Qualification Certificates: For video surveillance, cameras, camera-supporting equipment, accessories, and components, from manufacturer.
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
   d. Field quality-control reports.
   e. Operation and Maintenance Data: For cameras, power supplies, infrared illuminators, monitors, videotape recorders, digital video recorders, video switches, and control-station components to include in emergency, operation, and maintenance manuals. Include the following:
      1) Lists of spare parts and replacement components recommended to be stored at the site for ready access.
5. Warranty: Sample of special warranty.

F. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NECA 1.
3. Comply with NFPA 70.
4. Electronic data exchange between video surveillance system with an access-control system shall comply with SIA TVAC.

G. Project Conditions
1. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
   a. Control Station: Rated for continuous operation in ambient temperatures of 60 to 85 deg F (16 to 29 deg C) and a relative humidity of 20 to 80 percent, noncondensing.
   b. Interior, Controlled Environment: System components, except central-station control unit, installed in air-conditioned **OR** temperature-controlled, **as directed**, interior environments shall be rated for continuous operation in ambient temperatures of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 1 enclosures.
   c. Interior, Uncontrolled Environment: System components installed in non-air-conditioned **OR** non-temperature-controlled, **as directed**, interior environments shall be rated for continuous operation in ambient temperatures of 0 to 122 deg F (minus 18 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 3R **OR** Type 4 **OR** Type 12 **OR** Type 12K, **as directed**, enclosures.
   d. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambient temperatures of minus 30 to plus 122 deg F (minus 34 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h) and snow cover up to 24 inches (610 mm) thick, **as directed**. Use NEMA 250, Type 3 **OR** Type 3R **OR** Type 3S **OR** Type 4 **OR** Type 4X, **as directed**, enclosures.
   e. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.

f. Corrosive Environment: System components subject to corrosive fumes, vapors, and wind-driven salt spray in coastal zones. Use NEMA 250, Type 4X **OR** Type 6P, **as directed**, enclosures.
g. Security Environment: Camera housing for use in high-risk areas where surveillance equipment may be subject to physical violence.

H. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of cameras, equipment related to camera operation, and control-station equipment that fail in materials or workmanship within specified warranty period.
a. Warranty Period: Three years from date of Final Completion.

1.2 PRODUCTS

A. System Requirements
1. Video-signal format shall comply with NTSC standard, composite interlaced video. Composite video-signal termination shall be 75 ohms.
2. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor's entry connection to components.
a. Minimum Protection for Power Connections 120 V and More: Auxiliary panel suppressors complying with requirements in Division 16 Section "Transient Voltage Suppression."
b. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Connections: Comply with requirements in Division 16 Section "Transient Voltage Suppression" as recommended by manufacturer for type of line being protected.
3. Tamper Protection: Tamper switches on enclosures, control units, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled. Control-station, control-unit alarm display shall identify tamper alarms and indicate locations.

B. Standard Cameras
1. B/W Camera:
a. Comply with UL 639.
b. Pickup Device: CCD interline transfer, 252,000 512(H) by 492(V) pixels, **unless directed otherwise**.
c. Horizontal Resolution: 380 lines.
d. Signal-to-Noise Ratio: Not less than 46 dB.
e. With AGC, manually selectable on or off.
f. Sensitivity: Camera shall provide usable images in low-light conditions, delivering an image at a scene illumination, as directed by the Owner, with camera AGC off, **as directed**.
OR
Sensitivity: Camera shall deliver 1-V peak-to-peak video signal at the minimum specified light level. Illumination for the test shall be with lamps rated at approximately 2200-K color temperature, and with camera AGC off.
g. Manually selectable modes for backlight compensation or normal lighting.
h. Scanning Synchronization: Determined by external synch over the coaxial cable. Camera shall revert to internally generated synchronization on loss of external synch signal.
i. Motion Detector: Built-in digital.
2. Color Camera:
a. Comply with UL 639.
b. Pickup Device: CCD interline transfer, 380,000 771(H) by 492(V) pixels, **unless directed otherwise**.
c. Horizontal Resolution: 480 lines.
d. Signal-to-Noise Ratio: Not less than 50 dB, with camera AGC off.

e. With AGC, manually selectable on or off.
f. Sensitivity: Camera shall provide usable images in low-light conditions, delivering an image at a scene illumination, as directed by the Owner, with camera AGC off, **as directed**.
OR
Sensitivity: Camera shall deliver 1-V peak-to-peak video signal at the minimum specified light level. Illumination for the test shall be with lamps rated at approximately 2200-K color temperature, and with camera AGC off.
g. Manually selectable modes for backlight compensation or normal lighting.
h. Scanning Synchronization: Determined by external synch over the coaxial cable. Camera shall revert to internally generated synchronization on loss of external synch signal.
i. White Balance: Auto-tracing white balance, with manually settable fixed balance option.
j. Motion Detector: Built-in digital.

3. Automatic Color Dome Camera: Assembled and tested as a manufactured unit, containing dome assembly, color camera, motorized pan and tilt, zoom lens, and receiver/driver.
a. Comply with UL 639.
b. Pickup Device: CCD interline transfer, 380,000 768(H) by 494(V) pixels, **unless directed otherwise**.
c. Horizontal Resolution: 480 lines.
d. Signal-to-Noise Ratio: Not less than 50 dB, with camera AGC off.
e. With AGC, manually selectable on or off.
f. Sensitivity: Camera shall provide usable images in low-light conditions, delivering an image at a scene illumination, as directed by the Owner, with camera AGC off, **as directed**.
OR
Sensitivity: Camera shall deliver 1-V peak-to-peak video signal at the minimum specified light level. Illumination for the test shall be with lamps rated at approximately 2200-K color temperature, and with camera AGC off.
g. Manually selectable modes for backlight compensation or normal lighting.
h. Pan and Tilt: Direct-drive motor, 360-degree rotation angle, and 180-degree tilt angle. Pan-and-tilt speed shall be controlled by operator. Movement from preset positions shall be not less than 300 degrees per second.
i. Preset Positioning: Eight user-definable scenes, each allowing 16-character titles. Controls shall include the following:
1) In "sequence mode," camera shall continuously sequence through preset positions, with dwell time and sequencing under operator control.
2) Motion detection shall be available at each camera position.
3) Up to four preset positions may be selected to be activated by an alarm. Each of the alarm positions may be programmed to output a response signal.
j. Scanning Synchronization: Determined by external synch over the coaxial cable. Camera shall revert to internally generated synchronization on loss of external synch signal.
k. White Balance: Auto-tracing white balance, with manually settable fixed balance option.
l. Motion Detector: Built-in digital.
m. Dome shall support multiplexed control communications using coaxial cable recommended by manufacturer.

C. Submersible Cameras
1. Camera: Color, designed for underwater monitoring and for inspecting pipes and storm drains. Attributes as follows:
a. Infrared LEDs to provide illumination in zero-light conditions.
b. 60-foot (18.3-m) factory-installed cable with BNC connector for video and a 2.1-mm jack for 12-V dc power supply.
c. An adjustable swivel mount and attachment base.
d. Pickup Device: CCD interline transfer, 290,000 500(H) by 580(V) pixels, **unless directed otherwise**.

e. Horizontal Resolution: 380 lines.
f. Signal-to-Noise Ratio: Not less than 50 dB.
g. With AGC, from 4 to 39 dB.
h. Sensitivity: Camera shall provide usable images in low-light conditions, delivering an image at a scene illumination of 0.1 lux at f/2.0.
i. Scanning Synchronization: Internal.
j. White Balance: Auto-tracing white balance, for colors ranging from 2800 to 8200 deg K.

D. Reinforced Dome Cameras
1. Camera: Designed for high-abuse locations, with a weathertight semirecessed **OR** surface, **as directed**, mounting, impact-resistance polycarbonate dome, and heavy-gage, 6061 T6 aluminum body.
a. Suitable for exterior environment, rated for continuous operation in ambient temperatures of minus 40 to plus 122 deg F (minus 40 to plus 50 deg C) dry bulb and up to 85 percent relative humidity.
b. Pickup Device: CCD interline transfer, 290,000 510(H) by 492(V) pixels, **unless directed otherwise**.
c. Horizontal Resolution: 350 lines.
d. Signal-to-Noise Ratio: Not less than 46 dB.
e. With AGC and automatic backlight compensation.
f. Sensitivity: Camera shall provide usable images in low-light conditions, delivering an image at a scene illumination of 6 lux at f/2.0.
g. Scanning Synchronization: Determined by external synch over the coaxial cable. Camera shall revert to internally generated synchronization on loss of external synch signal.
h. White Balance: Auto-tracing white balance.

E. Lenses
1. Description: Optical-quality coated lens, designed specifically for video-surveillance applications and matched to specified camera. Provide color-corrected lenses with color cameras.
a. Auto-Iris Lens: Electrically controlled iris with circuit set to maintain a constant video level in varying lighting conditions.
b. Fixed Lens: With calibrated focus ring.
c. Zoom Lens: Motorized, remote-controlled unit, rated as "quiet operating." Features include the following:
1) Electrical Leads: Filtered to minimize video signal interference.
2) Motor Speed: Variable.
3) Lens shall be available with preset positioning capability to recall the position of specific scenes.

F. Power Supplies
1. Low-voltage power supplies matched for voltage and current requirements of cameras and accessories, and of type as recommended by manufacturer of camera, infrared illuminator, **as directed**, and lens.
a. Enclosure: NEMA 250, Type 1 **OR** Type 3 **OR** Type 4X, **as directed**.

G. Infrared Illuminators
1. Description: Lighting fixtures that emit light only in the infrared spectrum, suitable for use with cameras indicated, for nighttime surveillance, without emitting visible light.
a. Field-Selectable Beam Patterns: Narrow, medium, and wide.
b. Rated Lamp Life: More than 8000 hours.
c. Power Supply: 12-V ac/dc **OR** 120-V ac, **as directed**.
2. Area Coverage: Illumination to 150 feet (50 m) in a narrow beam pattern.
3. Exterior housings shall be suitable for same environmental conditions as the associated camera.

H. Camera-Supporting Equipment

1. Minimum Load Rating: Rated for load in excess of the total weight supported times a minimum safety factor of two.
2. Pan Units: Motorized automatic-scanning units arranged to provide remote-controlled manual and automatic camera panning action, and equipped with matching mounting brackets.
   a. Scanning Operation: Silent, smooth, and positive.
   b. Stops: Adjustable without disassembly, to limit the scanning arc.
3. Pan-and-Tilt Units: Motorized units arranged to provide remote-controlled aiming of cameras with smooth and silent operation, and equipped with matching mounting brackets.
   a. Panning Rotation: 0 to 355 degrees, with adjustable stops.
   b. Tilt Movement: 90 degrees, plus or minus 5 degrees, with adjustable stops.
   c. Speed: 12 degrees per second in both horizontal and vertical planes.
   d. Wiring: Factory prewired for camera and zoom lens functions and pan-and-tilt power and control.
   e. Built-in encoders or potentiometers for position feedback, and thermostat-controlled heater, **as directed**.
   f. Pan-and-tilt unit shall be available with preset positioning capability to recall the position of a specific scene.
4. Mounting Brackets for Fixed Cameras: Type matched to items supported and mounting conditions. Include manual pan-and-tilt adjustment.
5. Protective Housings for Fixed and Movable Cameras: Steel or 6061 T6 aluminum, **as directed**, enclosures with internal camera mounting and connecting provisions that are matched to camera/lens combination and mounting and installing arrangement of camera to be housed.
   a. Tamper switch on access cover sounds an alarm signal when unit is opened or partially disassembled. Central-control unit shall identify tamper alarms and indicate location in alarm display. Tamper switches and central-control unit are specified in Division 13 Section "Intrusion Detection."
   b. Camera Viewing Window: Polycarbonate **OR** Lexan, **as directed**, window, aligned with camera lens.
   c. Duplex Receptacle: Internally mounted.
   d. Alignment Provisions: Camera mounting shall provide for field aiming of camera and permit removal and reinstallation of camera lens without disturbing camera alignment.
   e. Built-in, thermostat-activated heater and blower units. Units shall be automatically controlled so the environmental limits of the camera equipment are not exceeded.
   f. Sun shield shall not interfere with normal airflow around the housing.
   g. Mounting bracket and hardware for wall or ceiling mounting of the housing. Bracket shall be of same material as the housing; mounting hardware shall be stainless steel.
   h. Finish: Housing and mounting bracket shall be factory finished using manufacturer's standard finishing process suitable for the environment.
   i. Enclosure Rating: as directed by the Owner.

I. Monitors
1. Monochrome:
   a. Metal cabinet units designed for continuous operation.
   b. Screen Size (Diagonal Dimension): as directed by the Owner.
   c. Horizontal Resolution: 600 lines, minimum, at center.
   d. Minimum Front Panel Devices and Controls: Power switch; power-on indicator; and brightness, horizontal-hold, vertical-hold, and contrast controls.
   e. Mounting: Adjustable tilting and training.
   f. Mounting: Single, 14-inch (356-mm) **OR** Dual, 9-inch (229-mm), **as directed**, vertical, EIA 19-inch (483-mm) electronic equipment rack or cabinet complying with CEA 310-E.
   g. Electrical: 120-V ac, 60 Hz.
2. Color:
   a. Metal cabinet units designed for continuous operation.
   b. Screen Size (Diagonal Dimension): as directed by the Owner.
   c. Horizontal Resolution: 300 lines.

d. Minimum Front Panel Devices and Controls: Power switch; power-on indicator; and brightness, contrast, color, and tint controls.
e. Degaussing: Automatic.
f. Mounting: Single, 14-inch (356-mm) **OR** Dual, 9-inch (229-mm), **as directed**, vertical, EIA 19-inch (483-mm) electronic equipment rack or cabinet complying with CEA 310-E.
g. Electrical: 120-V ac, 60 Hz.

J. Videotape Recorders
1. Description: Industrial, time-lapse type recorder, designed for continuous operation. Tape format is 1/2 inch (13 mm) using industrial-grade, T-120 cassettes.
a. Horizontal Resolution: 400 lines, minimum.
b. Recording Heads: Rotary-scan type.
c. Integral Timer: Permits programming of recording operation for adjustable daily and weekly periods.
d. Time-Lapse Operating Modes: Multiple, covering 24 to 240 hours, minimum.
e. Other Operating Modes:
1) Manual play and recording at two- and six-hour speeds.
2) Forward and reverse high-speed search.
3) Reverse, slow, and single-frame play.
f. Alarm Recording: Operating mode is automatically switched from time-lapse to two- or six-hour recording mode when an externally generated alarm signal is received.
g. Audio Recording: 70 to 7000 Hz. Phono and microphone input; phono output.
h. Time and Date Generator: Records time and date legend in corner of recorded scenes.
i. Tape Counter: Displays tape position.
j. Manual Recording Lock: Key or keypad operated. Prevents unauthorized tampering or control changes during preset operation.
k. Signal-to-Noise Ratio: 45 dB for video output in standard play mode.
l. Mounting: Standard 19-inch (483-mm) rack complying with CEA 310-E, or freestanding desktop.

K. Digital Video Recorders
1. Description: Digital, time-lapse type, full-frame and motion recorder, with removable hard drive.
a. Recording Time: 400 hours minimum.
b. Resolution: 720 by 480 lines, minimum.
c. Programming shall be from trackball and push buttons on face of the recorder, settings shall be displayed on any video monitor connected to the recorder. Programming shall include the following:
1) Motion analysis graph.
2) Password protection.
3) Alarm and timer controls.
4) Continuous recording option.
5) Time-lapse operating modes.
6) Search video by time, event, or motion.
d. Programming: SmartMedia card for software updating, image archiving, and image transfer to a PC.
e. Storage: 80-GB, **unless directed otherwise**, removable hard drive. Software shall permit hot-swapping drives.
f. Compression: MPEG-2.
g. Time and Date Generator: Records time (hr:min:sec) and date legend of each frame.
h. Audio Recording: 70 to 7000 Hz. Phono and microphone input; phono output.
i. Mounting: Standard 19-inch (483-mm) rack complying with CEA 310-E, or freestanding desktop.

L. Network Video Recorders
1. External storage or internal 250-1, 500-GB hard disk drive.
a. Video and audio recording over TCP/IP network.

b. Video recording of MPEG-2 and MPEG-4 streams.
c. Video recording up to 48 Mbps for internal storage and up to 100 Mbps for external storage.
d. Duplex Operation: Simultaneous recording and playback.
e. Continuous and alarm-based recording.
f. Full-Featured Search Capabilities: Search based on camera, time, or date.
g. Automatic data replenishment to ensure recording even if network is down.
h. Digital certification by watermarking.
i. Internal RAID storage or non-RAID storage of up to 1500 GB.
j. Capable of adding external RAID storage up to 7000 GB for models with no internal storage.
k. Full integration with LAN, Intranet, or Internet through standard Web browser or video management software.
l. Integrated Web server FTP server functionality.
m. Supports up to 16, 32, or 64 devices.

M. Digital Switchers
1. Quad Switch: For displaying images from four cameras on a single monitor. Provide color switcher if one or more cameras or monitors are in color.
a. Controls: Unit-mounted front panel.
b. Resolution: 720 by 480 lines, **unless directed otherwise**.
c. Modes: Auto, manual, and alarm. In manual mode, each channel can also be viewed in single display mode. In the event of an alarm, alarming channel shall automatically switch to full screen. If several alarms are activated, channels in alarm shall be in auto-switching mode.
d. Channel Loss Alarm: Audible buzzer; occurrence details shall be recorded.
e. Time: Indicate date and time.
f. Timing of Auto-Switcher: 1 to 30 seconds, selectable.
g. Mounting: Standard 19-inch (483-mm) rack complying with CEA 310-E, or freestanding desktop.
2. Manual Switch Bank: Low-loss, high-isolation, multiple-video switch to allow manual switching of multiple quad switches and cameras to a single output. Switches shall be illuminated.
3. Sequential Switchers: Automatically sequence outputs of multiple cameras to single monitor and videotape recorder.
a. Switching Time Interval: Continuously adjustable, 5 to 20 seconds minimum, with manual override.
b. Skip-Sequential-Hold Switch: One for each camera, with LED to indicate active camera.
c. Camera Identification Legend: Either on-screen message or label at skip-sequential switch.
d. Alarm Switching: In the event of an alarm, alarming channel shall automatically switch the monitor to full screen.
e. Mounting: Standard 19-inch (483-mm) rack complying with CEA 310-E.
4. PTZ Controls: Arranged for multiple-camera control, with switches to select camera to be controlled.
a. Pan-and-Tilt Control: Joystick type.
b. Zoom Control: Momentary-contact, "in-out" push button.
c. Automatic-Scan Control: A push button for each camera with pan capability that places camera in automatic-scanning mode.

N. IP Video Systems
1. Description:
a. System shall provide high-quality delivery and processing of IP-based video, audio, and control data using standard Ethernet-based networks.
b. System shall have seamless integration of all video surveillance and control functions.

c. Graphical user interface software shall manage all IP-based video matrix switching and camera control functions, two-way audio communication, alarm monitoring and control, and recording and archive/retrieval management. IP system shall also be capable of integrating into larger system environments.
d. System design shall include all necessary compression software for high-performance, dual-stream, MPEG-2/MPEG-4 video. Unit shall provide connections for all video cameras, camera PTZ control data, bidirectional audio, discreet sensor inputs, and control system outputs.
e. All camera signals shall be compressed, encoded, and delivered onto the network for processing and control by the IP video-management software.
f. Camera system units shall be ruggedly built and designed for extreme adverse environments, complying with NEMA Type environmental standards.
g. Encoder/decoder combinations shall place video, audio, and data network stream that can be managed from multiple workstations on the user's LAN or WAN.
h. All system interconnect cables, workstation PCs, PTZ joysticks, and network intermediate devices shall be provided for full performance of specified system.

O. Video Motion Sensors (Interior)
1. Device Performance: Detect changes in video signal within a user-defined protected zone. Video inputs shall be composite video as defined in SMPTE 170M. Provide an alarm output for each video input.
a. Detect movement within protected zone of intruders wearing clothing with a reflectivity that differs from that of background scene by a factor of two. Reject all other changes in video signal.
b. Modular design that allows for expansion or modification of number of inputs.
c. Controls:
1) Size of detection zones.
2) Sensitivity of detection of each protected zone.
d. Mounting: Standard 19-inch (483-mm) rack complying with CEA 310-E.

P. Control Stations
1. Description: Heavy-duty, freestanding, modular, metal furniture units arranged to house electronic equipment. Coordinate component arrangement and wiring with components and wiring of other systems.
2. Equipment Mounting: Standard 19-inch (483-mm) rack complying with CEA 310-E.
3. Normal System Power Supply: 120 V, 60 Hz, through a locked disconnect device and an isolation transformer in central-station control unit. Central-station control unit shall supply power to all components connected to it unless otherwise indicated.
4. Power Continuity for Control Station: Batteries in power supplies of central-station control units and individual system components shall maintain continuous system operation during outages of both normal and backup ac system supply.
a. Batteries: Rechargeable, valve-regulated, recombinant, sealed, lead-acid type with nominal 10-year life expectancy. Capacity adequate to operate portions of system served including audible trouble signal devices for up to four hours and audible and visual alarm devices under alarm conditions for an additional 10 minutes.
b. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Charger shall recharge fully discharged battery within 24 hours.
5. Annunciation: Indicate change in system condition and switching of system or component to backup power.

Q. Signal Transmission Components
1. Cable: Coaxial cable elements have 75-ohm nominal impedance. Comply with requirements in Division 16 Section "Conductors and Cables for Electronic Safety and Security."
2. Video Surveillance Coaxial Cable Connectors: BNC type, 75 ohms. Comply with requirements in Division 16 Section "Conductors and Cables for Electronic Safety and Security."

1.3 EXECUTION

A. Examination
1. Examine pathway elements intended for cables. Check raceways and other elements for compliance with space allocations, installation tolerance, hazards to camera installation, and other conditions affecting installation.
2. Examine roughing-in for LAN, WAN, and IP network before device installation.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Wiring
1. Comply with requirements in Division 16 Section "Raceways and Boxes."
OR
Wiring Method: Install cables in raceways unless otherwise indicated.
a. Except raceways are not required in accessible indoor ceiling spaces and attics.
OR
Except raceways are not required in hollow gypsum board partitions.
b. Conceal raceways and wiring except in unfinished spaces.
2. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
3. Splices, Taps, and Terminations: For power and control wiring, use numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
4. For LAN connection and fiber-optic and copper communication wiring, comply with Division 16 Sections "Communications Backbone Cabling" and "Communications Horizontal Cabling."
5. Grounding: Provide independent-signal circuit grounding recommended in writing by manufacturer.

C. Video Surveillance System Installation
1. Install cameras and infrared illuminators level and plumb.
2. Install cameras with 84-inch- (2134-mm-) minimum clear space below cameras and their mountings. Change type of mounting to achieve required clearance.
3. Set pan unit and pan-and-tilt unit stops to suit final camera position and to obtain the field of view required for camera. Connect all controls and alarms, and adjust.
4. Install power supplies and other auxiliary components at control stations unless otherwise indicated.
5. Install tamper switches on components indicated to receive tamper switches, arranged to detect unauthorized entry into system-component enclosures and mounted in self-protected, inconspicuous positions.
6. Avoid ground loops by making ground connections only at the control station.
a. For 12- and 24-V dc cameras, connect the coaxial cable shields only at the monitor end.
7. Identify system components, wiring, cabling, and terminals according to Division 16 Section "Electrical Identification."

D. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
a. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
b. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. Prepare video-surveillance equipment for acceptance and operational testing as follows:
1) Prepare equipment list described in "Submittals" Article.

2) Verify operation of auto-iris lenses.
3) Set back-focus of fixed focal length lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Adjust until image is in focus with and without the filter.
4) Set back-focus of zoom lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Additionally, set zoom to full wide angle and aim camera at an object 50 to 75 feet (17 to 23 m) away. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.
5) Set and name all preset positions; consult Owner's personnel.
6) Set sensitivity of motion detection.
7) Connect and verify responses to alarms.
8) Verify operation of control-station equipment.

c. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
d. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.

3. Video surveillance system will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

E. Adjusting
1. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Tasks shall include, but are not limited to, the following:
a. Check cable connections.
b. Check proper operation of cameras and lenses. Verify operation of auto-iris lenses and adjust back-focus as needed.
c. Adjust all preset positions; consult Owner's personnel.
d. Recommend changes to cameras, lenses, and associated equipment to improve Owner's use of video surveillance system.
e. Provide a written report of adjustments and recommendations.

F. Cleaning
1. Clean installed items using methods and materials recommended in writing by manufacturer.
2. Clean video-surveillance-system components, including camera-housing windows, lenses, and monitor screens.

G. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain video-surveillance equipment.

END OF SECTION 28 21 31 00

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Task	Specification	Specification Description
28 21 31 00	28 16 11 00b	Security Access
28 42 11 00	22 12 23 26	Underground Storage Tanks

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SECTION 28 46 00 00 - OIL/WATER SEPARATOR

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for oil/water separator. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Scope
1. The separator shall be designed for gravity separation of sand, grit, settleable solids, or semisolids, and free oils (hydrocarbons and other petroleum products) from wastewater. Separator shall be installed belowground with top access at or above grade level. The source of the influent to the separator shall be gravity flow from storm water runoff, hydrocarbon spills, and/or cleaning/maintenance operations.

C. Performance
1. Influent Characteristics
a. Provide separator designed for intermittent and variable flows of water, oil, or any combination of non-emulsified oil-water mixtures. Minimum separator retention time shall be 10 minutes. Operating temperatures of the influent oil in water mixture shall range from 40 degrees F. to 80 degrees F. The specific gravity of the oils at operating temperatures shall range from 0.71 to 0.92. The specific gravity of the fresh water at operating temperatures shall range from 1.00 to 1.03.
2. Effluent Characteristics
a. The free oil and grease concentration in the effluent from the separator shall not exceed 10 mg/l (10 PPM) to satisfy requirements of the NPDES stormwater discharge permit. To achieve this goal, it will be necessary to remove all free oil droplets equal to and greater than 20 microns.

D. Design Criteria
1. The separator shall be listed to Underwriters' Laboratories UL-SU2215. Construction and performance of the oil/water separators shall be in accordance with UL-SU2215. Provide certification documentation detailing criteria under which the system was tested. UL-SU2215 label shall be prominently displayed on manway covers.
2. Separator shall be designed in accordance with Stokes Law and the American Petroleum Institute Publication 421, "Monographs on Refinery Environmental Control - Management of Water Discharges; Design and Operation of Oil/Water Separators." Effective surface area calculations, signed and stamped by a Registered Professional Engineer shall be submitted to document specified effluent quality based on complete removal of the specified oil globule at design flow. A separator with lower effective surface area than required is not permissible.
3. Separator capacities, dimensions, construction, and thickness shall be in strict accordance with Underwriters' Laboratories, Subject UL-58 Standard for Safety, Steel Underground Tanks for Flammable and Combustible Liquids, September 30, 1997, Double Wall construction with 360 degree Steel Secondary Containment. The inner steel tank shall be completely contained within the outer steel tank, enclosing 100% of the tank volume. The tank shall have a double steel shell with a space between the layers. The space between the inner and outer steel walls shall be monitored with an approved electronic leak detection device through a pipe that extends vertically to the top of the tank from a small sump at the bottom. Tank construction using thin walled primary tank with external fiberglass jacket shall not be permissible.
4. Separator Corrosion Control System shall be in strict accordance with Underwriters' Laboratories Inc. Subject UL-1746 Standard for External Corrosion Protection Systems for Steel Underground Storage Tanks and the HighGuard® External Corrosion Protection Specifications.

5. Oil/water separator shall comply with National Fire Protection Association NFPA 30 Flammable and Combustible Liquids Code, 2003 Edition.
6. Separator vessel volume shall allow for a hydraulic retention time of ten (10) minutes to ensure laminar flow conditions which result in hydraulic uniformity and high effluent quality. Volume reduction will adversely affect separator performance by increasing horizontal velocity and turbulence, therefore a separator of smaller volume is not permissible.
7. Separator shall be the standard patented product of a steel tank manufacturer regularly engaged in the production of such equipment. Manufacturer shall have at least 20 years experience in manufacturing similar units for identical applications. No subcontracting of tank fabrication shall be permitted.
8. Separator shall be fabricated, inspected, and tested for leakage before shipment from the factory by manufacturer as a completely assembled vessel ready for installation.
9. Separator shall be cylindrical, horizontal, atmospheric-type steel vessel intended for the separation and storage of flammable and combustible liquids. The separator shall have the structural strength to withstand static and dynamic hydraulic loading while empty and during operating conditions. The Oil/Water Separator's dimensions and thickness shall be in strict compliance with Roark's Formulas for Stress and Strain as presented in UL 58, September 30, 1997. Calculations, signed and stamped by a Registered Professional Engineer shall be submitted to document structural strength under specified overbearing or external pressure. A separator with a reduced shell thickness is not permissible.
10. Separator shall have an oil storage capacity equal to about 43% of the total vessel volume and an emergency oil spill capacity equal to 80% of the total vessel volume.
11. To prevent extensive shutdown and maintenance, the separator design must allow solids to fall unhindered by turbulence, and oil droplets to rise without risk of re-emulsifying due to collisions with interfering solids. The use of plastic perforated tubes, spherical balls, or irregular shaped media will increase the facility's maintenance costs and shall not be permitted.
12. Separator shall consist of inlet and outlet connections, integral sand interceptor compartment, non-clogging flow distributor and energy dissipater device, stationary under flow baffle, presettling chamber for solids, sludge baffle, oil coalescing chamber with removable parallel flat/corrugated plate coalescer, with removable plates, and sectionalized removable polypropylene impingement coalescers to optimize separation of free oil from water, effluent downcomer positioned to prevent discharge of free oil that has been separated from the water, access ways for coalescers and each chamber, fittings for vent, oil pump-out, sampling, gauging, leak detection, and lifting lugs.

E. Submittals:
1. Shop Drawings: shop drawings for oil water separators shall show principal dimensions and location of all fittings.
2. Instructions: provide three complete sets of installation, operation, and maintenance instructions with separator.
3. Quality Control: Quality control, inspection procedures, and reports shall be considered part of the submittal package.

F. Warranty
1. The manufacturer shall warrant its products to be free from defects in material and workmanship for a period of one year from the date of shipment. The warranty shall be limited to repair or replacement of the defective part(s).
2. The manufacturer's warranty shall be standard limited warranty in effect at time of purchase.

1.2 PRODUCTS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Highland Tank, One Highland Road, Box 338, Stoystown, PA 15563, Phone 814-893-5701, FAX 893-6126, E-mail ows.info@highlandtank.com, Website http://www.highlandtank.com

B. Product

1. Provide and install Highland Tank Model HTC Series "G" UL-SU2215 approved Belowground Double Wall Parallel Flat/Corrugated Plate Gravity Displacement Oil/Water Separator with Integral Sand Interceptor Compartment. Separator shall be furnished with oil level alarm and leak detection systems. Oil/Water Separator shall be of capacity to comply with Spill Prevention Control and Countermeasures (SPCC) plan requirements at the facility. The sizing of this oil/water separator is consistent with industry protocols for complying with the minimum federal spill and discharge regulations therefore a separator of smaller volume is not permissible.
2. Separator shall be furnished with a Corella™ inclined parallel flat/corrugated plate coalescer to simultaneously separate free oil droplets and settleable or suspended solids particles from water without clogging of the coalescer.

C. Description

1. Separator shall be standard prefabricated inclined parallel flat/corrugated plate, gravity displacement type unit.
2. Separator shall be cylindrical with capacities, dimensions, construction, and thickness in strict accordance with Underwriters' Laboratories Subject 58, Double Wall construction using flat-flanged heads. Separator shall comply with National Fire Protection Association NFPA 30 Flammable and Combustible Liquids Code, 2003 Edition.
3. The separator shall be a pre-packaged, pre-engineered, ready to install unit consisting of:
   a. An influent connection, flanged. An internal influent nozzle at the inlet end of the separator. Nozzle discharge to be located at the furthest diagonal point from the effluent discharge opening.
   b. An integral sand interceptor compartment containing one (1) manhole, UL approved, complete with extension, cover, gasket, and bolts. A heavy-duty bulkhead shall retain sand, grit, settleable solids or semisolids and prevent them from entering the separation chamber. Bulkhead shall have a transfer pipe.
   c. A velocity head diffusion baffle at the inlet to:
      1) reduce horizontal velocity and flow turbulence.
      2) distribute the flow equally over the separators cross sectional area.
      3) direct the flow in a serpentine path in order to enhance hydraulic characteristics and fully utilize all separator volume.
      4) completely isolate all inlet turbulence from the separation chamber.
   d. A sediment chamber to disperse flow and collect oily solids and sediments.
   e. A sludge baffle to retain settleable solids and sediment and prevent them from entering the separation chamber.
   f. An Oil/Water Separation Chamber containing a removable Corella™ inclined parallel flat/corrugated plate coalescer. The coalescer shall have individual removable plates, sloped towards the sediment chamber. Each coalescing polate shall be flat on the top and corrugated on the bottom. The flat top plate shall resist clogging and clotting with solids. The corrugations of each of the plate bottoms shall be shaped and positioned to enhance collisions between the rising oil droplets and coalesce between them thereby improving separator efficiency. The coalescer shall:
      1) effect separation of oil and solids from all strata of the wastewater stream.
      2) shorten the vertical distance that an oil globule or solid particle has to rise or sink, respectively, for effective removal. Minimum plate gap to be 3/4".
      3) enhance coalescence and agglomeration by causing the smaller globules and particles (those possessing smaller rising/settling rates) to coalesce and collect on the plates thereby forming larger globules and particles that separate rapidly in water.
      4) direct the flow paths of the separated oil to the surface of the separator and separated solids to the bottom of the separator.
      5) allow solids to fall unhindered by turbulence, and oil droplets to rise without risk of re-emulsifying due to collisions with interfering solids.
   g. The Oil/Water Separation Chamber shall also contain a sectionalized removable "Petro-Screen"™ polypropylene impingement coalescer designed to intercept oil globules of less

than 20 microns in diameter. Heavy, one-piece impingement coalescers are not permissible.

h. An internal effluent downcomer at the outlet end of the separator, to allow for discharge from the bottom of the separation chamber only.

i. An effluent connection, flanged.

j. Fittings for vent, interface/level sensor, leak detection, waste oil pump-out, sampling, and gauge.

k. Two (2) manholes, UL approved, complete with extension, cover, gasket, and bolts. One manway shall be placed between the inlet and the parallel flat/corrugated plate coalescer to facilitate access into sediment chamber for solids removal. One manway shall be placed between the parallel flat/corrugated plate coalescer and outlet to facilitate access into the oil water separation chamber for oil removal.

l. Lifting lugs at balancing points for handling and installation.

m. Identification plates: Plates shall be affixed in prominent location and be durable and legible throughout equipment life.

n. HighGuard® Corrosion Protection System consisting of:
   1) Isolation Spool Pieces
   2) Dielectric Isolation Gaskets and Bushings
   3) External surfaces commercial grit blast, coated 75 mils DFT Self-Reinforcing Polyurethane.

o. Internal surfaces commercial grit blast and coated with 10 mils DFT heavy duty Polyurethane.

D. Accessories

1. Separator shall be supplied with an audible and visual alarm system that indicates hi oil level (visual only) and hi hi oil level (audible and visual) of oil storage in the oil/water separator and an audible and visual leak detection alarm system that indicates hydrocarbon and/or water in the interstice. A silence control shall be provided for the audible alarms. Level sensor(s) shall be intrinsically safe. Level sensor floats shall be made of stainless steel. The control panel shall contain both level sensor and detection control. The control panel shall be NEMA 4. Power to the control panel shall be as directed by the Owner.
2. Separator shall be supplied with Polyester Hold-down straps.
3. Separator shall be supplied with prefabricated Concrete Deadman Anchors.
4. Separator shall be supplied with cylindrical and/or rectangular steel Grade Level Manways designed to AASHTO H20 requirements.

1.3 EXECUTION

A. Installation

1. Installation shall be in strict compliance with manufacturer's instructions and shall comply with all applicable local, state, and federal requirements.

END OF SECTION 28 46 00 00

SECTION 28 46 21 17 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for digital, addressable fire alarm system. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Fire-alarm control unit.
b. Manual fire-alarm boxes.
c. System smoke detectors.
d. Nonsystem smoke detectors.
e. Heat detectors.
f. Notification appliances.
g. Firefighters' two-way telephone communication service.
h. Magnetic door holders.
i. Remote annunciator.
j. Addressable interface device.
k. Digital alarm communicator transmitter.
l. Radio alarm transmitter.
m. System printer.

C. Definitions
1. LED: Light-emitting diode.
2. NICET: National Institute for Certification in Engineering Technologies.

D. System Description
1. Noncoded, UL-certified **OR** FMG-placarded, **as directed**, addressable system, with multiplexed signal transmission, dedicated to fire-alarm service only.
2. Noncoded addressable system, with automatic sensitivity control of certain smoke detectors and multiplexed signal transmission, dedicated to fire-alarm service only.

E. Performance Requirements
1. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event," **as directed.**

F. Submittals
1. General Submittal Requirements:
a. Submittals shall be approved by authorities having jurisdiction prior to submitting them to the Owner.
b. Shop Drawings shall be prepared by persons with the following qualifications:
1) Trained and certified by manufacturer in fire-alarm system design.
2) NICET-certified fire-alarm technician, Level III **OR** Level IV, **as directed**, minimum.
3) Licensed or certified by authorities having jurisdiction.
2. Product Data: For each type of product indicated.
3. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.

a. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
b. Include voltage drop calculations for notification appliance circuits.
c. Include battery-size calculations.
d. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
e. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
f. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
g. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.

4. Delegated-Design Submittal: For smoke and heat detectors indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   a. Drawings showing the location of each smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the detector.
   b. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72.
5. Qualification Data: For qualified Installer.
6. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
7. Field quality-control reports.
8. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. Deliver copies to authorities having jurisdiction and include the following:
   a. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
   b. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
   c. Record copy of site-specific software.
   d. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:
      1) Frequency of testing of installed components.
      2) Frequency of inspection of installed components.
      3) Requirements and recommendations related to results of maintenance.
      4) Manufacturer's user training manuals.
   e. Manufacturer's required maintenance related to system warranty requirements.
   f. Abbreviated operating instructions for mounting at fire-alarm control unit.
   g. Copy of NFPA 25.
9. Software and Firmware Operational Documentation:
   a. Software operating and upgrade manuals.
   b. Program Software Backup: On magnetic media or compact disk, complete with data files.
   c. Device address list.
   d. Printout of software application and graphic screens.

G. Quality Assurance
1. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
2. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II **OR** Level III **OR** Level IV, **as directed**, technician.
3. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL.
6. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.
7. NFPA Certification: Obtain certification according to NFPA 72 in the form of a placard by an FMG-approved alarm company.
8. NFPA Certification: Obtain certification according to NFPA 72 by agency having jurisdiction.

H. Project Conditions
1. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:
   a. Notify the Owner no fewer than two days in advance of proposed interruption of fire-alarm service.
   b. Do not proceed with interruption of fire-alarm service without the Owner written permission.

I. Sequencing And Scheduling
1. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.
2. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

J. Software Service Agreement
1. Comply with UL 864.
2. Technical Support: Beginning with Final Completion, provide software support for two years.
3. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Final Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
   a. Provide 30 days' notice to the Owner to allow scheduling and access to system and to allow the Owner to upgrade computer equipment if necessary.

1.2 PRODUCTS

A. Systems Operational Description
1. Fire-alarm signal initiation shall be by one or more of the following devices and systems, **as directed**:
   a. Manual stations.
   b. Heat detectors.
   c. Flame detectors.
   d. Smoke detectors.
   e. Duct smoke detectors.
   f. Verified automatic alarm operation of smoke detectors.
   g. Automatic sprinkler system water flow.
   h. Heat detectors in elevator shaft and pit.

i. Fire-extinguishing system operation.
j. Fire standpipe system.

2. Fire-alarm signal shall initiate the following actions:
   a. Continuously operate alarm notification appliances.
   b. Identify alarm at fire-alarm control unit and remote annunciators, **as directed**.
   c. Transmit an alarm signal to the remote alarm receiving station.
   d. Unlock electric door locks in designated egress paths.
   e. Release fire and smoke doors held open by magnetic door holders.
   f. Activate voice/alarm communication system.
   g. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
   h. Activate smoke-control system (smoke management) at firefighter smoke-control system panel.
   i. Activate stairwell and elevator-shaft pressurization systems.
   j. Close smoke dampers in air ducts of designated air-conditioning duct systems.
   k. Recall elevators to primary or alternate recall floors.
   l. Activate emergency lighting control.
   m. Activate emergency shutoffs for gas and fuel supplies.
   n. Record events in the system memory.
   o. Record events by the system printer.
3. Supervisory signal initiation shall be by one or more of the following devices and actions:
   a. Valve supervisory switch.
   b. Low-air-pressure switch of a dry-pipe sprinkler system.
   c. Elevator shunt-trip supervision.
4. System trouble signal initiation shall be by one or more of the following devices and actions:
   a. Open circuits, shorts, and grounds in designated circuits.
   b. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
   c. Loss of primary power at fire-alarm control unit.
   d. Ground or a single break in fire-alarm control unit internal circuits.
   e. Abnormal ac voltage at fire-alarm control unit.
   f. Break in standby battery circuitry.
   g. Failure of battery charging.
   h. Abnormal position of any switch at fire-alarm control unit or annunciator.
   i. Fire-pump power failure, including a dead-phase or phase-reversal condition.
   j. Low-air-pressure switch operation on a dry-pipe or preaction sprinkler system.
5. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators, **as directed**. Record the event on system printer.

B. Fire-Alarm Control Unit
1. General Requirements for Fire-Alarm Control Unit:
   a. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.
      1) System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
      2) Include a real-time clock for time annotation of events on the event recorder and printer.
   b. Addressable initiation devices that communicate device identity and status.
      1) Smoke sensors shall additionally communicate sensitivity setting and allow for adjustment of sensitivity at fire-alarm control unit, **as directed**.
      2) Temperature sensors shall additionally test for and communicate the sensitivity range of the device.
   c. Addressable control circuits for operation of mechanical equipment.

2. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
   a. Annunciator and Display: Liquid-crystal type, 1 **OR** 2 **OR** 3, **as directed**, line(s) of 40 **OR** 80, **as directed**, characters, minimum.
   b. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters, **as directed**.
3. Circuits:
   a. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class A.
      1) Initiating Device Circuits: Style D **OR** Style E, **as directed**.
      2) Notification Appliance Circuits: Style Z.
      3) Signaling Line Circuits: Style 2 **OR** Style 5 **OR** Style 6 **OR** Style 7, **as directed**.
      4) Install no more than 50 addressable devices on each signaling line circuit.
   b. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class B.
      1) Initiating Device Circuits: Style A **OR** Style B **OR** Style C, **as directed**.
      2) Notification Appliance Circuits: Style W **OR** Style X **OR** Style Y, **as directed**.
      3) Signaling Line Circuits: Style 0.5 **OR** Style 1 **OR** Style 3 **OR** Style 3.5 **OR** Style 4 **OR** Style 4.5, **as directed**.
      4) Install no more than 50 addressable devices on each signaling line circuit.
   c. Serial Interfaces: Two RS-232 ports for printers.
4. Stairwell Pressurization: Provide an output signal using an addressable relay to start the stairwell pressurization system. Signal shall remain on until alarm conditions are cleared and fire-alarm system is reset. Signal shall not stop in response to alarm acknowledge or signal silence commands.
   a. Pressurization starts when any alarm is received at fire-alarm control unit.
   b. Alarm signals from smoke detectors at pressurization air supplies have a higher priority than other alarm signals that start the system.
5. Smoke-Alarm Verification:
   a. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
   b. Activate an NRTL-listed and -approved "alarm-verification" sequence at fire-alarm control unit and detector.
   c. Record events by the system printer.
   d. Sound general alarm if the alarm is verified.
   e. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.
6. Notification Appliance Circuit: Operation shall sound in a <**Insert pattern**>.
7. Elevator Recall:
   a. Smoke detectors at the following locations shall initiate automatic elevator recall. Alarm-initiating devices, except those listed, shall not start elevator recall, **as directed**.
      1) Elevator lobby detectors except the lobby detector on the designated floor.
      2) Smoke detector in elevator machine room.
      3) Smoke detectors in elevator hoistway.
   b. Elevator lobby detectors located on the designated recall floors shall be programmed to move the cars to the alternate recall floor.
   c. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.
      1) Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.
8. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke barrier walls shall be **OR** not be, **as directed**, connected to fire-alarm system.
9. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-

adjustment schedule changes in system memory, and print out the final adjusted values on system printer.

10. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.
11. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided in a separate cabinet located in the fire command center **OR** as a special module that is part of fire-alarm control unit, **as directed**.
    a. Indicated number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711 and be listed by an NRTL.
        1) Allow the application of and evacuation signal to indicated number of zones and, at same time, allow voice paging to the other zones selectively or in any combination.
        2) Programmable tone and message sequence selection.
        3) Standard digitally recorded messages for "Evacuation" and "All Clear."
        4) Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification appliance circuits of fire-alarm control unit.
    b. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.
    c. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.
12. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.
13. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals **OR** supervisory and digital alarm communicator transmitters **OR** digital alarm radio transmitters, **as directed**, shall be powered by 24-V dc source.
    a. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.
14. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
    a. Batteries: Sealed lead calcium **OR** Sealed, valve-regulated, recombinant lead acid **OR** Vented, wet-cell pocket, plate nickel cadmium, **as directed**.
15. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

C. Manual Fire-Alarm Boxes
    1. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
        a. Single-action mechanism, breaking-glass or plastic-rod **OR** pull-lever, **as directed**, type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
        b. Double-action mechanism requiring two actions to initiate an alarm, breaking-glass or plastic-rod **OR** pull-lever, **as directed**, type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.

c. Station Reset: Key- or wrench-operated switch.
d. Indoor Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
e. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

D. System Smoke Detectors
1. General Requirements for System Smoke Detectors:
a. Comply with UL 268; operating at 24-V dc, nominal.
b. Detectors shall be four **OR** two, **as directed**,-wire type.
c. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
d. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
e. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
f. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status, **as directed**.
g. Remote Control: Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
1) Rate-of-rise temperature characteristic shall be selectable at fire-alarm control unit for 15 or 20 deg F (8 or 11 deg C) per minute.
2) Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F (57 or 68 deg C).
3) Provide multiple levels of detection sensitivity for each sensor.
2. Photoelectric Smoke Detectors:
a. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
b. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
1) Primary status.
2) Device type.
3) Present average value.
4) Present sensitivity selected.
5) Sensor range (normal, dirty, etc.).
3. Ionization Smoke Detector:
a. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
b. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
1) Primary status.
2) Device type.
3) Present average value.
4) Present sensitivity selected.
5) Sensor range (normal, dirty, etc.).
4. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
a. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
b. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
1) Primary status.
2) Device type.
3) Present average value.

4) Present sensitivity selected.
5) Sensor range (normal, dirty, etc.).

c. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
d. Each sensor shall have multiple levels of detection sensitivity.
e. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
f. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

E. Nonsystem Smoke Detectors
1. Single-Station Smoke Detectors:
a. Comply with UL 217; suitable for NFPA 101, residential occupancies; operating at 120-V ac with 9-V dc battery as the secondary power source. Provide with "low" or "missing" battery chirping-sound device, **as directed**.
b. Auxiliary Relays: One Form C rated at 0.5 A **OR** Form A and one Form C, both rated at 0.5 A, **as directed**.
c. Audible Notification Appliance: Piezoelectric sounder rated at 90 dBA at 10 feet (3 m) according to UL 464.
d. Visible Notification Appliance: 177-cd strobe.
e. Heat sensor, 135 deg F (57 deg C) combination rate-of-rise, **as directed**, and fixed temperature.
f. Test Switch: Push to test; simulates smoke at rated obscuration.
g. Tandem Connection: Allow tandem connection of number of indicated detectors; alarm on one detector shall actuate notification on all connected detectors.
h. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
i. Self-Restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.
j. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status, **as directed**.
2. Single-Station Duct Smoke Detectors:
a. Comply with UL 268A; operating at 120-V ac.
b. Sensor: LED or infrared light source with matching silicon-cell receiver.
1) Detector Sensitivity: Smoke obscuration between 2.5 and 3.5 percent/foot (0.008 and 0.011 percent/mm) when tested according to UL 268A.
c. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. The fixed base shall be designed for mounting directly to air duct. Provide terminals in the fixed base for connection to building wiring.
1) Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
d. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
e. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

F. Heat Detectors
1. General Requirements for Heat Detectors: Comply with UL 521.
2. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (57 deg C) or a rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.
a. Mounting: Adapter plate for outlet box mounting **OR** Twist-lock base interchangeable with smoke-detector bases, **as directed**.
b. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

3. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F (88 deg C).
   a. Mounting: Adapter plate for outlet box mounting **OR** Twist-lock base interchangeable with smoke-detector bases, **as directed**.
   b. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Continuous Linear Heat-Detector System:
   a. Detector Cable: Rated detection temperature 155 deg F (68 deg C). NRTL listed for "regular" service and a standard environment. Cable includes two steel actuator wires twisted together with spring pressure, wrapped with protective tape, and finished with PVC outer sheath. Each actuator wire is insulated with heat-sensitive material that reacts with heat to allow the cable twist pressure to short- circuit wires at the location of elevated temperature.
   b. Control Unit: Two-zone or multizone unit as indicated. Provide same system power supply, supervision, and alarm features as specified for fire-alarm control unit.
   c. Signals to Fire-Alarm Control Unit: Any type of local system trouble shall be reported to fire-alarm control unit as a composite "trouble" signal. Alarms on each detection zone shall be individually reported to central fire-alarm control unit as separately identified zones.
   d. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

G. Notification Appliances
1. General Requirements for Notification Appliances: Individually addressed, connected to a signaling line circuit, equipped for mounting as indicated and with screw terminals for system connections.
2. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, zoned as indicated, equipped for mounting as indicated and with screw terminals for system connections.
   a. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.
3. Chimes, Low-Level Output: Vibrating type, 75-dBA minimum rated output.
4. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.
5. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn, using the coded signal prescribed in UL 464 test protocol.
6. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.
   a. Rated Light Output:
      1) 15 **OR** 30 **OR** 75 **OR** 110 **OR** 177, **as directed**, cd.
         OR
         15/30/75/110 cd, selectable in the field.
   b. Mounting: Wall mounted unless otherwise indicated.
   c. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
   d. Flashing shall be in a temporal pattern, synchronized with other units.
   e. Strobe Leads: Factory connected to screw terminals.
   f. Mounting Faceplate: Factory finished, red **OR** white, **as directed**.
7. Voice/Tone Notification Appliances:
   a. Appliances shall comply with UL 1480 and shall be listed and labeled by an NRTL.
   b. High-Range Units: Rated 2 to 15 W.
   c. Low-Range Units: Rated 1 to 2 W.
   d. Mounting: Flush **OR** Semirecessed **OR** Surface mounted and bidirectional, **as directed**.

e. Matching Transformers: Tap range matched to acoustical environment of speaker location.

H. Firefighters' Two-Way Telephone Communication Service
1. Dedicated, two-way, supervised, telephone voice communication links between fire-alarm control unit, the fire command center, **as directed**, and remote firefighters' telephone stations. Supervised telephone lines shall be connected to talk circuits by controls in a control module. Provide the following:
a. Common-talk type for firefighter use only.
b. Selective-talk type for use by firefighters and fire wardens.
c. Controls to disconnect phones from talk circuits if too many phones are in use simultaneously.
d. Audible Pulse and Tone Generator, and High-Intensity Lamp: When a remote telephone is activated, it causes audible signal to sound and high-intensity lamp to flash.
e. Selector panel controls shall provide for simultaneous operation of up to six telephones in selected zones. Indicate ground faults and open or shorted telephone lines on the panel front by individual LEDs.
f. Display: Graphic **OR** Liquid-crystal digital, **as directed**, to indicate location of caller.
g. Remote Telephone Cabinet: Flush- or surface-mounted cabinet as indicated, factory-standard red finish, with handset.
1) Install one-piece handset to cabinet with vandal-resistant armored cord. Silk-screened or engraved label on cabinet door, designating "Fire Warden Phone" **OR** "Fire Emergency Phone", **as directed.**
2) With "break-glass" type door access lock.
h. Remote Telephone Jack Stations: Single-gang, stainless-steel-plate mounted plug, engraved "Fire Warden Phone" **OR** "Fire Emergency Phone", **as directed.**
i. Handsets: **<Insert number>** push-to-talk-type sets with noise-canceling microphone, **as directed**, stored in a cabinet adjacent to fire-alarm control unit **OR** in the fire command center, **as directed**.

I. Magnetic Door Holders
1. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.
a. Electromagnet: Requires no more than 3 W to develop 25-lbf (111-N) holding force.
b. Wall-Mounted Units: Flush mounted unless otherwise indicated.
c. Rating: 24-V ac or dc.
d. Rating: 120-V ac.
2. Material and Finish: Match door hardware.

J. Remote Annunciator
1. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
a. Mounting: Flush **OR** Surface, **as directed**, cabinet, NEMA 250, Type 1.
2. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

K. Addressable Interface Device
1. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.
2. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall **OR** to circuit-breaker shunt trip for power shutdown, **as directed**.

L. Digital Alarm Communicator Transmitter

1. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632 and be listed and labeled by an NRTL.
2. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture one **OR** two, **as directed**, telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either, **as directed**, line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.
3. Local functions and display at the digital alarm communicator transmitter shall include the following:
   a. Verification that both telephone lines are available.
   b. Programming device.
   c. LED display.
   d. Manual test report function and manual transmission clear indication.
   e. Communications failure with the central station or fire-alarm control unit.
4. Digital data transmission shall include the following:
   a. Address of the alarm-initiating device.
   b. Address **OR** Zone, **as directed**, of the supervisory signal.
   c. Address **OR** Zone, **as directed**, of the trouble-initiating device.
   d. Loss of ac supply or loss of power.
   e. Low battery.
   f. Abnormal test signal.
   g. Communication bus failure.
5. Secondary Power: Integral rechargeable battery and automatic charger.
6. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

M. Radio Alarm Transmitter
1. Transmitter shall comply with NFPA 1221 and shall be listed and labeled by an NRTL.
2. Comply with 47 CFR 90.
3. Description: Manufacturer's standard commercial product; factory assembled, wired, tested, and ready for installation and operation.
   a. Packaging: A single, modular, NEMA 250, Type 1 metal enclosure with a tamper-resistant flush tumbler lock.
   b. Signal Transmission Mode and Frequency: VHF or UHF 2-W power output, coordinated with operating characteristics of the established remote alarm receiving station designated by the Owner.
   c. Normal Power Input: 120-V ac.
   d. Secondary Power: Integral-sealed, rechargeable, 12-V battery and charger. Comply with NFPA 72 requirements for battery capacity; submit calculations.
   e. Antenna: Omnidirectional, coaxial half-wave, dipole type with driving point impedance matched to transmitter and antenna cable output impedance. Wind-load strength of antenna and mounting hardware and supports shall withstand 100 mph (160 km/h), **as directed**, with a gust factor of 1.3 without failure.
   f. Antenna Cable: Coaxial cable with impedance matched to the transmitter output impedance.
   g. Antenna-Cable Connectors: Weatherproof.
   h. Alarm Interface Devices: Circuit boards, modules, and other auxiliary devices, integral to the transmitter, matching fire-alarm and other system outputs to message-generating inputs of the transmitter that produce required message transmissions.
4. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit or from its own internal sensors or controls and shall automatically transmit signal along with a unique code that identifies the transmitting station to the remote alarm receiving station. Transmitted messages shall correspond to standard designations for fire-

reporting system to which the signal is being transmitted and shall include separately designated messages in response to the following events or conditions:

a. Transmitter Low-Battery Condition: Sent when battery voltage is below 85 percent of rated value.
b. System Test Message: Initiated manually by a test switch within the transmitter cabinet, or automatically at an optionally preselected time, once every 24 hours, with transmission time controlled by a programmed timing device integral to transmitter controls.
c. Transmitter Trouble Message: Actuated by failure, in excess of one-minute duration, of the transmitter normal power source, derangement of the wiring of the transmitter, or any alarm input interface circuit or device connected to it.
d. Local Fire-Alarm-System Trouble Message: Initiated by events or conditions that cause a trouble signal to be indicated on the building system.
e. Local Fire-Alarm-System Alarm Message: Actuated when the building system goes into an alarm state. Identifies device that initiated the alarm.
f. Local Fire-Alarm-System Supervisory-Alarm Message: Actuated when the building alarm system indicates a supervisory alarm, **as directed**.

N. System Printer
1. Printer shall be listed and labeled by an NRTL as an integral part of fire-alarm system.

O. Device Guards
1. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.
a. Factory fabricated and furnished by manufacturer of device.
b. Finish: Paint of color to match the protected device.

1.3 EXECUTION

A. Equipment Installation
1. Comply with NFPA 72 for installation of fire-alarm equipment.
2. Equipment Mounting: Install fire-alarm control unit on concrete base with tops of cabinets not more than 72 inches (1830 mm) above the finished floor. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
a. Install seismic bracing. Comply with requirements in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting: Install fire-alarm control unit on finished floor with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
a. Comply with requirements for seismic-restraint devices specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
4. Install wall-mounted equipment, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
a. Comply with requirements for seismic-restraint devices specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
5. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.
a. Connect new equipment to existing control panel in existing part of the building.
b. Connect new equipment to existing monitoring equipment at the supervising station.

c. Expand, modify, and supplement existing control **OR** monitoring, **as directed**, equipment as necessary to extend existing control **OR** monitoring, **as directed**, functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.

6. Smoke- or Heat-Detector Spacing:
   a. Comply with NFPA 72, "Smoke-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for smoke-detector spacing.
   b. Comply with NFPA 72, "Heat-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for heat-detector spacing.
   c. Smooth ceiling spacing shall not exceed 30 feet (9 m)
   d. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A or Appendix B in NFPA 72.
   e. HVAC: Locate detectors not closer than 3 feet (1 m) **OR** 5 feet (1.5 m), **as directed**, from air-supply diffuser or return-air opening.
   f. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture.
7. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.
8. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.
9. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.
10. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.
11. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.
12. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling.
13. Device Location-Indicating Lights: Locate in public space near the device they monitor.
14. Fire-Alarm Control Unit: Surface mounted, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
15. Annunciator: Install with top of panel not more than 72 inches (1830 mm) above the finished floor.
16. Antenna for Radio Alarm Transmitter: Mount to building structure where indicated. Use mounting arrangement and substrate connection that will resist 100-mph (160-km/h), **as directed**, wind load with a gust factor of 1.3 without damage.

B. Connections
1. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Division 08 Section "Door Hardware". Connect hardware and devices to fire-alarm system.
   a. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.
2. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet (1 m) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
   a. Alarm-initiating connection to smoke-control system (smoke management) at firefighter smoke-control system panel.
   b. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
   c. Smoke dampers in air ducts of designated air-conditioning duct systems.
   d. Alarm-initiating connection to elevator recall system and components.
   e. Alarm-initiating connection to activate emergency lighting control.
   f. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.

g. Supervisory connections at valve supervisory switches.
h. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
i. Supervisory connections at elevator shunt trip breaker.
j. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
k. Supervisory connections at fire-pump engine control panel.

C. Identification
1. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
2. Install framed instructions in a location visible from fire-alarm control unit.

D. Grounding
1. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

E. Field Quality Control
1. Field tests shall be witnessed by authorities having jurisdiction.
2. Tests and Inspections:
a. Visual Inspection: Conduct visual inspection prior to testing.
1) Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
2) Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
b. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
c. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
d. Test audible appliances for the private operating mode according to manufacturer's written instructions.
e. Test visible appliances for the public operating mode according to manufacturer's written instructions.
f. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
3. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
4. Fire-alarm system will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.
6. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.
7. Annual Test and Inspection: One year after date of Final Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

END OF SECTION 28 46 21 17

SECTION 28 46 21 17a - ZONED (DC LOOP) FIRE-ALARM SYSTEM

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for zoned (DC loop) fire alarm system. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Fire-alarm control unit.
b. Manual fire-alarm boxes.
c. System smoke detectors.
d. Nonsystem smoke detectors.
e. Heat detectors.
f. Notification appliances.
g. Magnetic door holders.
h. Remote annunciator.
i. Digital alarm communicator transmitter.
j. Radio alarm transmitter.

C. Definitions
1. LED: Light-emitting diode.
2. NICET: National Institute for Certification in Engineering Technologies.

D. System Description
1. Noncoded system, dedicated to fire-alarm service only.

E. Submittals
1. General Submittal Requirements:
a. Submittals shall be approved by authorities having jurisdiction prior to submitting them to the Owner.
b. Shop Drawings shall be prepared by persons with the following qualifications:
1) Trained and certified by manufacturer in fire-alarm system design.
2) NICET-certified fire-alarm technician, Level III **OR** Level IV**OR** one who meets the requirements necessary for certification, **as directed**, minimum.
3) Licensed or certified by authorities having jurisdiction.
2. Product Data: For each type of product indicated.
3. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.
a. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
b. Include voltage drop calculations for notification appliance circuits.
c. Include battery size calculations.
d. Include performance parameters and installation details for each detector, verifying that each detector is listed for the complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
e. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.

f. Include floor plans to indicate final outlet locations showing zone designation of each device. Show size and route of cable and conduits.

4. Delegated-Design Submittal: For smoke and heat detectors indicated to comply with performance requirements and design criteria, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.
   a. Drawings showing the location of each smoke and heat detector, the ratings of each, and installation details as needed to comply with the listing conditions of the detector.
   b. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72.
5. Qualification Data: For qualified Installer.
6. Field quality-control reports.
7. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. Deliver copies to authorities having jurisdiction, **as directed**, and include the following:
   a. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
   b. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
   c. Record copy of site-specific software.
   d. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:
      1) Frequency of testing of installed components.
      2) Frequency of inspection of installed components.
      3) Requirements and recommendations related to results of maintenance.
      4) Manufacturer's user training manuals.
   e. Manufacturer's required maintenance related to system warranty requirements.
   f. Abbreviated operating instructions for mounting at fire-alarm control unit.
   g. Copy of NFPA 25.

F. Quality Assurance
1. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
2. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II **OR** Level III **OR** Level IV **OR** one who meets the requirements necessary for certification, **as directed**, technician.
3. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Project Conditions
1. Interruption of Existing Fire-alarm Service: Do not interrupt fire-alarm service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:
   a. Notify the Owner no fewer than two days in advance of proposed interruption of fire-alarm service.
   b. Do not proceed with interruption of fire-alarm service without the Owner 's written permission.

H. Sequencing And Scheduling
1. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.

2. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

1.2 PRODUCTS

A. Systems Operational Description
1. Fire-alarm signal initiation shall be by one or more of the following devices and systems, **as directed**:
a. Manual stations.
b. Heat detectors.
c. Smoke detectors.
d. Duct smoke detectors.
e. Automatic sprinkler system water flow.
f. Fire-extinguishing system operation.
g. Fire standpipe system.
2. Fire-alarm signal shall initiate the following actions:
a. Continuously operate alarm notification appliances.
b. Identify alarm zone at fire-alarm control unit and remote annunciators, **as directed**.
c. Transmit an alarm signal to the remote alarm receiving station.
3. Supervisory signal initiation shall be by one or more of the following devices and systems:
a. Valve supervisory switch.
4. System trouble signal initiation shall be by one or more of the following devices and actions:
a. Open circuits, shorts, and grounds in designated circuits.
b. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
c. Loss of primary power at fire-alarm control unit.
d. Ground or a single break in fire-alarm control unit internal circuits.
e. Abnormal ac voltage at fire-alarm control unit.
f. Break in standby battery circuitry.
g. Failure of battery charging.
h. Abnormal position of any switch at fire-alarm control unit or annunciator, **as directed**.
5. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators, **as directed**.

B. Fire-Alarm Control Unit
1. General Requirements for Fire-Alarm Control Unit:
a. Modular, power-limited design with electronic modules, UL 864 listed.
1) Include a real-time clock for time annotation of events.
2. Alphanumeric Display and System Controls: Display alarm, supervisory, and component status messages and the programming and control menu.
a. Annunciator and Display: Liquid-crystal type, one line of 40 **OR** 80, **as directed**, characters, minimum.
3. Circuits:
a. No Fewer Than Five Initiating Device Circuits:
1) Four circuits, NFPA 72, Class B.
2) One circuit(s), NFPA 72, Class A, Style 6
b. No Fewer Than Two Notification Appliance Circuits: NFPA 72, Class B, Style Y.
4. Notification Appliance Circuit: Operation shall sound in a <**Insert pattern**>.
5. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke barrier walls shall be **OR** not be, **as directed**, connected to fire-alarm system.
6. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.
7. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals **OR**

supervisory and digital alarm communicator transmitters **OR** digital alarm radio transmitters, **as directed**, shall be powered by the 24-V dc source.
   a. Alarm current draw of the entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.
8. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
   a. Batteries: Sealed lead calcium **OR** Sealed, valve-regulated, recombinant lead acid **OR** Vented, wet-cell pocket, plate nickel cadmium, **as directed**.
9. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

C. Manual Fire-Alarm Boxes
1. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
   a. Single-action mechanism, breaking-glass or plastic-rod **OR** pull-lever, **as directed**, type.
   b. Double-action mechanism requiring two actions to initiate an alarm, breaking-glass or plastic-rod **OR** pull-lever, **as directed**, type.
   c. Station Reset: Key- or wrench-operated switch.
   d. Indoor Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
   e. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

D. System Smoke Detectors
1. General Requirements for System Smoke Detectors:
   a. Operating at 24-V dc, nominal.
   b. Detectors shall be four **OR** two, **as directed**,-wire type.
   c. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
   d. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
   e. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status, **as directed**.
   f. Provide multiple levels of detection sensitivity for each sensor, with alarm-verification feature, **as directed**.
2. Photoelectric Smoke Detectors: Comply with UL 268.
3. Ionization Smoke Detector: Comply with UL 268.
4. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
   a. Remote indication and test, **as directed**, station. Operating key switch initiates an alarm test, **as directed**.
   b. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
   c. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
   d. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

E. Nonsystem Smoke Detectors
1. Single-Station Smoke Detectors:

a. Comply with UL 217; suitable for NFPA 101, residential occupancies; operating at 120-V ac with 9-V dc battery as the secondary power source. Provide with "low" or "missing" battery chirping-sound device, **as directed**.
b. Auxiliary Relays: One Form C rated at 0.5 A **OR** Form A and one Form C, both rated at 0.5 A, **as directed**.
c. Audible Notification Appliance: Piezoelectric sounder rated at 90 dBA at 10 feet (3 m) according to UL 464.
d. Visible Notification Appliance: 177-cd strobe.
e. Heat sensor, 135 deg F (57 deg C) combination rate-of-rise and fixed temperature, **as directed**.
f. Test Switch: Push-to-test; simulates smoke at rated obscuration.
g. Tandem Connection: Allow tandem connection of number of indicated detectors; alarm on one detector shall actuate notification on all connected detectors.
h. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
i. Self-Restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.
j. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status, **as directed**.

2. Single-Station Duct Smoke Detectors:
a. Comply with UL 268A; operating at 120-V ac.
b. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. The fixed base shall be designed for mounting directly to air duct. Provide terminals in the fixed base for connection to building wiring.
1) Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
c. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
d. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

F. Heat Detectors
1. General Requirements for Heat Detectors: Comply with UL 521.
2. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (57 deg C) or a rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.
a. Mounting: Adapter plate for outlet box mounting **OR** Twist-lock base interchangeable with smoke-detector bases, **as directed**.
3. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F (88 deg C).
a. Mounting: Adapter plate for outlet box mounting **OR** Twist-lock base interchangeable with smoke-detector bases, **as directed**.

G. Notification Appliances
1. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, zoned as indicated, equipped for mounting as indicated and with screw terminals for system connections.
a. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.
2. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.
3. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn, using the coded signal prescribed in UL 464 test protocol.

4. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.
   a. Rated Light Output:
      1) Indicated on Drawings.
      2) 15 **OR** 30 **OR** 75 **OR** 110 **OR** 177, **as directed**, cd.
         OR
         15/30/75/110 cd, selectable in the field.
   b. Mounting: Indicated on Drawings **OR** Wall mounted, **as directed**.
   c. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
   d. Flashing shall be in a temporal pattern, synchronized with other units.
   e. Strobe Leads: Factory connected to screw terminals.
   f. Mounting Faceplate: Factory finished, red **OR** white, **as directed**.

H. Magnetic Door Holders
1. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.
   a. Electromagnet: Requires no more than 3 W to develop 25-lbf (111-N) holding force.
   b. Wall-Mounted Units: Flush mounted unless otherwise indicated.
   c. Rating: 24-V ac or dc.
   d. Rating: 120-V ac.
2. Material and Finish: Match door hardware.

I. Remote Annunciator
1. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
   a. Mounting: Flush **OR** Surface, **as directed**, cabinet, NEMA 250, Type 1.
2. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

J. Digital Alarm Communicator Transmitter
1. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632 and be listed and labeled by an NRTL.
2. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture one **OR** two, **as directed**, telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either, **as directed**, line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.
3. Local functions and display at the digital alarm communicator transmitter shall include the following:
   a. Verification that both telephone lines are available.
   b. Programming device.
   c. LED display.
   d. Manual test report function and manual transmission clear indication.
   e. Communications failure with the central station or fire-alarm control unit.
4. Digital data transmission shall include the following:
   a. Zone of the alarm initiating device.
   b. Zone of the supervisory signal.
   c. Zone of the trouble initiating device.

d. Loss of ac supply or loss of power.
e. Low battery.
f. Abnormal test signal.
g. Communication bus failure.

5. Secondary Power: Integral rechargeable battery and automatic charger.
6. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

K. Radio Alarm Transmitter

1. Transmitter shall comply with NFPA 1221 and shall be listed and labeled by an NRTL.
2. Comply with 47 CFR 90.
3. Description: Manufacturer's standard commercial product; factory assembled, wired, tested, and ready for installation and operation.
   a. Packaging: A single, modular, NEMA 250, Type 1 metal enclosure with a tamper-resistant flush tumbler lock.
   b. Signal Transmission Mode and Frequency: VHF or UHF 2-W power output, coordinated with operating characteristics of the established remote alarm receiving station designated by the Owner.
   c. Normal Power Input: 120-V ac.
   d. Secondary Power: Integral-sealed, rechargeable, 12-V battery and charger. Comply with NFPA 72 requirements for battery capacity; submit calculations.
   e. Antenna: Omnidirectional, coaxial half-wave, dipole type with driving point impedance matched to transmitter and antenna cable output impedance. Wind-load strength of antenna and mounting hardware and supports shall withstand 100 mph (160 km/h) with a gust factor of 1.3 without failure.
   f. Antenna Cable: Coaxial cable with impedance matched to the transmitter output impedance.
   g. Antenna-Cable Connectors: Weatherproof.
   h. Alarm Interface Devices: Circuit boards, modules, and other auxiliary devices, integral to the transmitter, matching fire-alarm and other system outputs to message-generating inputs of the transmitter that produce required message transmissions.
4. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit or from its own internal sensors or controls and shall automatically transmit signal along with a unique code that identifies the transmitting station to the remote alarm receiving station. Transmitted messages shall correspond to standard designations for fire-reporting system to which the signal is being transmitted and shall include separately designated messages in response to the following events or conditions:
   a. Transmitter Low-Battery Condition: Sent when battery voltage is below 85 percent of rated value.
   b. System Test Message: Initiated manually by a test switch within the transmitter cabinet, or automatically at an optionally preselected time, once every 24 hours, with transmission time controlled by a programmed timing device integral to transmitter controls.
   c. Transmitter Trouble Message: Actuated by failure, in excess of one-minute duration, of the transmitter normal power source, derangement of the wiring of the transmitter, or any alarm input interface circuit or device connected to it.
   d. Local Fire-Alarm-System Trouble Message: Initiated by events or conditions that cause a trouble signal to be indicated on the building system.
   e. Local Fire-Alarm-System Alarm Message: Actuated when the building system goes into an alarm state. Identifies device that initiated the alarm.
   f. Local Fire-Alarm-System Supervisory-Alarm Message: Actuated when the building alarm system indicates a supervisory alarm, **as directed**.

L. Device Guards

1. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.
   a. Factory fabricated and furnished by manufacturer of the device.
   b. Finish: Paint of color to match the protected device.

1.3 EXECUTION

A. Equipment Installation
1. Comply with NFPA 72 for installation of fire-alarm equipment.
2. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.
   a. Connect new equipment to the existing control panel in the existing part of the building.
   b. Connect new equipment to the existing monitoring equipment at the supervising station.
   c. Expand, modify, and supplement the existing control **OR** monitoring, **as directed**, equipment as necessary to extend the existing control **OR** monitoring, **as directed**, functions to the new points. New components shall be capable of merging with the existing configuration without degrading the performance of either system.
3. Smoke- or Heat-Detector Spacing:
   a. Comply with NFPA 72, "Smoke-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for smoke-detector spacing.
   b. Comply with NFPA 72, "Heat-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for heat-detector spacing.
   c. Smooth ceiling spacing shall not exceed 30 feet (9 m), **as directed**.
   d. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A or Appendix B, **as directed**, in NFPA 72.
   e. HVAC: Locate detectors not closer than 3 feet (1 m) **OR** 5 feet (1.5 m), **as directed**, from air-supply diffuser or return-air opening.
   f. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture.
4. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.
5. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.
6. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.
7. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.
8. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.
9. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling.
10. Device Location-Indicating Lights: Locate in public space near the device they monitor.
11. Fire-Alarm Control Unit: Surface mounting, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
12. Annunciator: Install with top of panel not more than 72 inches (1830 mm) above the finished floor.
13. Antenna for Radio Alarm Transmitter: Mount to building structure where indicated. Use mounting arrangement and substrate connection that will resist 100-mph (160-km/h), **as directed**, wind load with a gust factor of 1.3 without damage.

B. Connections
1. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Division 08 Section "Door Hardware". Connect hardware and devices to fire-alarm system.
   a. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.

2. Connect supervised interface devices to the following devices and systems. Install the interface device less than 3 feet (1 m) from the device controlled.
   a. Smoke dampers in air ducts of designated air-conditioning duct systems.
   b. Supervisory connections at valve supervisory switches.
   c. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
   d. Supervisory connections at fire-pump engine control panel.

C. Identification
1. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
2. Install framed instructions in a location visible from fire-alarm control unit.

D. Grounding
1. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

E. Field Quality Control
1. Field tests shall be witnessed by authorities having jurisdiction.
2. Tests and Inspections:
   a. Visual Inspection: Conduct the visual inspection prior to testing.
      1) Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
      2) Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
   b. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing, and Maintenance" Chapter in NFPA 72.
   c. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
   d. Test visible appliances for the public operating mode according to manufacturer's written instructions.
   e. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
3. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
4. Fire-alarm system will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.
6. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.
7. Annual Test and Inspection: One year after date of Final Completion, test fire-alarm system complying with the visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

END OF SECTION 28 46 21 17a

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Task	Specification	Specification Description
28 49 11 00	28 16 11 00	Perimeter Security
28 49 11 00	28 16 11 00a	Intrusion Detection
28 49 11 00	28 16 11 00b	Security Access

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SECTION 31 01 20 00 - EARTHWORK

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for earthwork. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Preparing subgrades for slabs-on-grade, walks, pavements, turf and grasses, and plants.
b. Excavating and backfilling for buildings and structures.
c. Drainage course for concrete slabs-on-grade.
d. Subbase course for concrete walks and pavements.
e. Subbase course and base course for asphalt paving.
f. Subsurface drainage backfill for walls and trenches.
g. Excavating and backfilling trenches for utilities and pits for buried utility structures.
h. Excavating well hole to accommodate elevator-cylinder assembly.

C. Definitions
1. Backfill: Soil material or controlled low-strength material used to fill an excavation.
a. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
b. Final Backfill: Backfill placed over initial backfill to fill a trench.
2. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.
3. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.
4. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.
5. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
6. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
a. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by the Owner. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
b. Bulk Excavation: Excavation more than 10 feet (3 m) in width and more than 30 feet (9 m) in length.
c. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by the Owner. Unauthorized excavation, as well as remedial work directed by the Owner, shall be without additional compensation.
7. Fill: Soil materials used to raise existing grades.
8. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed 1 cu. yd. (0.76 cu. m) for bulk excavation or 3/4 cu. yd. (0.57 cu. m) for footing, trench, and pit excavation that cannot be removed by rock excavating equipment equivalent to the following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted:
a. Excavation of Footings, Trenches, and Pits: Late-model, track-mounted hydraulic excavator; equipped with a 42-inch- (1065-mm-) wide, maximum, short-tip-radius rock bucket; rated at not less than 138-hp (103-kW) flywheel power with bucket-curling force of not less than 28,700 lbf (128 kN) and stick-crowd force of not less than 18,400 lbf (82 kN) with extra-long reach boom; measured according to SAE J-1179.

b. Bulk Excavation: Late-model, track-mounted loader; rated at not less than 230-hp (172-kW) flywheel power and developing a minimum of 47,992-lbf (213.3-kN) breakout force with a general-purpose bare bucket; measured according to SAE J-732.

9. If Standard Penetration Values are used to Define Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material 3/4 cu. yd. (0.57 cu. m) or more in volume that exceed a standard penetration resistance of 100 blows/2 inches (97 blows/50 mm) when tested by a geotechnical testing agency, according to ASTM D 1586.
10. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
11. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.
12. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.
13. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

D. Submittals
1. Product Data: For each type of the following manufactured products required:
   a. Geotextiles.
   b. Controlled low-strength material, including design mixture.
   c. Geofoam.
   d. Warning tapes.
2. Samples: For the following products, in sizes indicated below:
   a. Geotextile: 12 by 12 inches (300 by 300 mm).
   b. Warning Tape: 12 inches (300 mm) long; of each color.
3. Qualification Data: For qualified testing agency.
4. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:
   a. Classification according to ASTM D 2487.
   b. Laboratory compaction curve according to ASTM D 698 **OR** ASTM D 1557, **as directed**.
5. Blasting plan approved by authorities having jurisdiction.
6. Seismic survey report from seismic survey agency.
7. Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by earth moving operations. Submit before earth moving begins.

E. Quality Assurance
1. Blasting:
   a. Blasting will not be allowed.
   OR
   Comply with applicable requirements in NFPA 495, "Explosive Materials Code," and prepare a blasting plan reporting the following:
      1) Types of explosive and sizes of charge to be used in each area of rock removal, types of blasting mats, sequence of blasting operations, and procedures that will prevent damage to site improvements and structures on Project site and adjacent properties.
      2) Seismographic monitoring during blasting operations.
2. Seismic Survey Agency: An independent testing agency, acceptable to authorities having jurisdiction, experienced in seismic surveys and blasting procedures to perform the following services:
   a. Report types of explosive and sizes of charge to be used in each area of rock removal, types of blasting mats, sequence of blasting operations, and procedures that will prevent damage to site improvements and structures on Project site and adjacent properties.

b. Seismographic monitoring during blasting operations.

3. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.
4. Pre-excavation Conference: Conduct conference at Project site.

F. Project Conditions

1. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth moving operations.
   a. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the Owner and authorities having jurisdiction.
   b. Provide alternate routes around closed or obstructed traffic ways if required by the Owner or authorities having jurisdiction.
2. Improvements on Adjoining Property: Authority for performing earth moving indicated on property adjoining the Owner's property will be obtained by the Owner before award of Contract.
3. Do not proceed with work on adjoining property until directed by the Owner.
4. Utility Locator Service: Notify utility locator service **OR** Miss Utility" **OR** "Call Before You Dig" **OR** "Dig Safe System" **OR** "One Call", **as directed**, for area where Project is located before beginning earth moving operations.
5. Do not commence earth moving operations until temporary erosion- and sedimentation-control measures, specified in Division 01 Section(s) "Temporary Facilities And Controls" OR Division 31 Section(s) "Site Clearing", **as directed**, are in place.
6. Do not commence earth moving operations until plant-protection measures specified in Division 01 Section "Temporary Tree And Plant Protection" are in place.
7. The following practices are prohibited within protection zones:
   a. Storage of construction materials, debris, or excavated material.
   b. Parking vehicles or equipment.
   c. Foot traffic.
   d. Erection of sheds or structures.
   e. Impoundment of water.
   f. Excavation or other digging unless otherwise indicated.
   g. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
8. Do not direct vehicle or equipment exhaust towards protection zones.
9. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

1.2 PRODUCTS

A. Soil Materials

1. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
2. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D 2487 **OR** Groups A-1, A-2-4, A-2-5, and A-3 according to AASHTO M 145, **as directed**, or a combination of these groups; free of rock or gravel larger than 3 inches (75 mm) in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.
3. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487 **OR** Groups A-2-6, A-2-7, A-4, A-5, A-6, and A-7 according to AASHTO M 145, **as directed**, or a combination of these groups.
   a. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.
4. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 12 percent passing a No. 200 (0.075-mm) sieve.
5. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 95 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 8 percent passing a No. 200 (0.075-mm) sieve.

6. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 12 percent passing a No. 200 (0.075-mm) sieve.
7. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a 1-inch (25-mm) sieve and not more than 8 percent passing a No. 200 (0.075-mm) sieve.
8. Drainage Course: Narrowly graded mixture of washed, **as directed**, crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch (37.5-mm) sieve and 0 to 5 percent passing a No. 8 (2.36-mm) sieve.
9. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch (25-mm) sieve and 0 to 5 percent passing a No. 4 (4.75-mm) sieve.
10. Sand: ASTM C 33; fine aggregate.
11. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

B. Geotextiles
1. Subsurface Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
   a. Survivability: Class 2; AASHTO M 288.
   b. Apparent Opening Size: No. 40 (0.425-mm) **OR** No. 60 (0.250-mm) **OR** No. 70 (0.212-mm), **as directed**, sieve, maximum; ASTM D 4751.
   c. Permittivity: 0.5 **OR** 0.2 **OR** 0.1, **as directed**, per second, minimum; ASTM D 4491.
   d. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.
2. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
   a. Survivability: Class 2; AASHTO M 288.
   b. Apparent Opening Size: No. 60 (0.250-mm) sieve, maximum; ASTM D 4751.
   c. Permittivity: 0.02 per second, minimum; ASTM D 4491.
   d. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

C. Controlled Low-Strength Material
1. Controlled Low-Strength Material: Self-compacting, low-density, **as directed**, flowable concrete material produced from the following:
   a. Portland Cement: ASTM C 150, Type I **OR** Type II **OR** Type III, **as directed**.
   b. Fly Ash: ASTM C 618, Class C or F.
   c. Normal-Weight Aggregate: ASTM C 33, 3/4-inch (19-mm) **OR** 3/8-inch (10-mm), **as directed**, nominal maximum aggregate size.
   d. Foaming Agent (if low-density, controlled low-strength material is required): ASTM C 869.
   e. Water: ASTM C 94/C 94M.
   f. Air-Entraining Admixture (not required for low-density, controlled low-strength material using foaming agent): ASTM C 260.
2. Produce low-density, controlled low-strength material with the following physical properties:
   a. As-Cast Unit Weight: 30 to 36 lb/cu. ft. (480 to 576 kg/cu. m) **OR** 36 to 42 lb/cu. ft. (576 to 675 kg/cu. m), **as directed**, at point of placement, when tested according to ASTM C 138/C 138M.
   b. Compressive Strength: 80 psi (550 kPa) **OR** 140 psi (965 kPa), **as directed**, when tested according to ASTM C 495.

   OR

   Produce conventional-weight, controlled low-strength material with 80-psi (550-kPa) **OR** 140-psi (965-kPa), **as directed**, compressive strength when tested according to ASTM C 495.

D. Geofoam

1. Extruded-Polystyrene Board Insulation: ASTM C 578, Type IV, 1.55-lb/cu. ft. (25-kg/cu. m) density, 25-psi (173-kPa) compressive strength **OR** Type X, 1.30-lb/cu. ft. (21-kg/cu. m) density, 15-psi (104-kPa) compressive strength **OR** Type VI, 1.80-lb/cu. ft. (29-kg/cu. m) density, 40-psi (276-kPa) compressive strength **OR** Type VII, 2.20-lb/cu. ft. (35-kg/cu. m) density, 60-psi (414-kPa) compressive strength **OR** Type V, 3.00-lb/cu. ft. (48-kg/cu. m) density, 100-psi (690-kPa) compressive strength, **as directed**.
2. Molded-Polystyrene Board Insulation: ASTM C 578, Type I, 0.90-lb/cu. ft. (15-kg/cu. m) density, 10-psi (69-kPa) compressive strength **OR** Type VIII, 1.15-lb/cu. ft. (18-kg/cu. m) density, 13-psi (90-kPa) compressive strength **OR** Type II, 1.35-lb/cu. ft. (22-kg/cu. m) density, 15-psi (104-kPa) compressive strength, **as directed**.
   a. Manufacture molded polystyrene with an inorganic mineral registered with the EPA and suitable for application as a termite deterrent.
3. Rigid Cellular Polystyrene Geofoam: ASTM D 6817, Type EPS 19, 1.15-lb/cu. ft. (18.4-kg/cu. m) density, 5.8-psi (40-kPa) compressive strength at 1 percent deformation; 16-psi (110-kPa) compressive strength at 10 percent deformation **OR** Type EPS 39, 2.40-lb/cu. ft. (38.4-kg/cu. m) density, 15-psi (103-kPa) compressive strength at 1 percent deformation; 40-psi (276-kPa) compressive strength at 10 percent deformation, **as directed**.
4. Connectors: Geofoam manufacturer's multibarbed, galvanized-steel sheet connectors **OR** Deformed steel reinforcing bars, 3/4 inch (19 mm) in diameter, **as directed**.

E. Accessories
1. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility; colored as follows:
   a. Red: Electric.
   b. Yellow: Gas, oil, steam, and dangerous materials.
   c. Orange: Telephone and other communications.
   d. Blue: Water systems.
   e. Green: Sewer systems.

   OR

   Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored as follows:
   f. Red: Electric.
   g. Yellow: Gas, oil, steam, and dangerous materials.
   h. Orange: Telephone and other communications.
   i. Blue: Water systems.
   j. Green: Sewer systems.

1.3 EXECUTION

A. Preparation
1. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth moving operations.
2. Protect and maintain erosion and sedimentation controls during earth moving operations.
3. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

B. Dewatering
1. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

2. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
   a. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

C. Explosives
1. Explosives: Do not use explosives.
   OR
   Explosives: Obtain written permission from authorities having jurisdiction before bringing explosives to Project site or using explosives on Project site.
   a. Perform blasting without damaging adjacent structures, property, or site improvements.
   b. Perform blasting without weakening the bearing capacity of rock subgrade and with the least-practicable disturbance to rock to remain.

D. Excavation, General
1. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.
   a. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
   b. Remove rock to lines and grades indicated to permit installation of permanent construction without exceeding the following dimensions:
      1) 24 inches (600 mm) outside of concrete forms other than at footings.
      2) 12 inches (300 mm) outside of concrete forms at footings.
      3) 6 inches (150 mm) outside of minimum required dimensions of concrete cast against grade.
      4) Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
      5) 6 inches (150 mm) beneath bottom of concrete slabs-on-grade.
      6) 6 inches (150 mm) beneath pipe in trenches, and the greater of 24 inches (600 mm) wider than pipe or 42 inches (1065 mm) wide.
2. Classified Excavation: Excavate to subgrade elevations. Material to be excavated will be classified as earth and rock. Do not excavate rock until it has been classified and cross sectioned by the Owner. The Contract Sum will be adjusted for rock excavation according to unit prices included in the Contract Documents. Changes in the Contract Time may be authorized for rock excavation.
   a. Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and other items indicated to be removed; together with soil, boulders, and other materials not classified as rock or unauthorized excavation.
      1) Intermittent drilling; blasting, if permitted; ram hammering; or ripping of material not classified as rock excavation is earth excavation.
   b. Rock excavation includes removal and disposal of rock. Remove rock to lines and subgrade elevations indicated to permit installation of permanent construction without exceeding the following dimensions:
      1) 24 inches (600 mm) outside of concrete forms other than at footings.
      2) 12 inches (300 mm) outside of concrete forms at footings.
      3) 6 inches (150 mm) outside of minimum required dimensions of concrete cast against grade.
      4) Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
      5) 6 inches (150 mm) beneath bottom of concrete slabs-on-grade.
      6) 6 inches (150 mm) beneath pipe in trenches, and the greater of 24 inches (600 mm) wider than pipe or 42 inches (1065 mm) wide.

E. Excavation For Structures
1. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch (25 mm). If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
   a. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
   b. Pile Foundations: Stop excavations 6 to 12 inches (150 to 300 mm) above bottom of pile cap before piles are placed. After piles have been driven, remove loose and displaced material. Excavate to final grade, leaving solid base to receive concrete pile caps.
   c. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch (25 mm). Do not disturb bottom of excavations intended as bearing surfaces.
2. Excavations at Edges of Tree- and Plant-Protection Zones:
   a. Excavate by hand to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
   b. Cut and protect roots according to requirements in Division 01 Section "Temporary Tree And Plant Protection".

F. Excavation For Walks And Pavements
1. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

G. Excavation For Utility Trenches
1. Excavate trenches to indicated gradients, lines, depths, and elevations.
   a. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.
2. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches (300 mm) higher than top of pipe or conduit unless otherwise indicated.
   a. Clearance: 12 inches (300 mm) each side of pipe or conduit **OR** As indicated, **as directed**.
3. Trench Bottoms (if a bedding course is not required under pipe and conduit): Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.
   a. For pipes and conduit less than 6 inches (150 mm) in nominal diameter, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
   b. For pipes and conduit 6 inches (150 mm) or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe or conduit circumference. Fill depressions with tamped sand backfill.
   c. For flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support conduit on an undisturbed subgrade.
   d. Excavate trenches 6 inches (150 mm) deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
4. Trench Bottoms (if a bedding course is required under pipe and conduit): Excavate trenches 4 inches (100 mm) deeper than bottom of pipe and conduit elevations to allow for bedding course. Hand-excavate deeper for bells of pipe.
   a. Excavate trenches 6 inches (150 mm) deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
5. Trenches in Tree- and Plant-Protection Zones:
   a. Hand-excavate to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.

b. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.
c. Cut and protect roots according to requirements in Division 01 Section "Temporary Tree And Plant Protection".

H. Excavation For Elevator Cylinder
1. Drill well hole plumb in elevator pit to accommodate installation of elevator-cylinder assembly. Coordinate with applicable requirements for diameter and tolerances in Division 14 Section(s) "Hydraulic Elevators" OR "Hydraulic Freight Elevators", **as directed**.
2. Provide well casing as necessary to retain walls of well hole.

I. Subgrade Inspection
1. Notify the Owner when excavations have reached required subgrade.
2. If the Owner determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
3. Proof-roll subgrade below the building slabs and pavements with a pneumatic-tired and loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons (13.6 tonnes) to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
a. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph (5 km/h).
b. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by the Owner, and replace with compacted backfill or fill as directed.
4. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
5. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by the Owner, without additional compensation.

J. Unauthorized Excavation
1. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi (17.2 MPa), may be used when approved by the Owner.
a. Fill unauthorized excavations under other construction, pipe, or conduit as directed by the Owner.

K. Storage Of Soil Materials
1. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
a. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

L. Backfill
1. Place and compact backfill in excavations promptly, but not before completing the following:
a. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
b. Surveying locations of underground utilities for Record Documents.
c. Testing and inspecting underground utilities.
d. Removing concrete formwork.
e. Removing trash and debris.
f. Removing temporary shoring and bracing, and sheeting.
g. Installing permanent or temporary horizontal bracing on horizontally supported walls.
2. Place backfill on subgrades free of mud, frost, snow, or ice.

M. Utility Trench Backfill
1. Place backfill on subgrades free of mud, frost, snow, or ice.

2. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
3. Trenches under Footings: Backfill trenches excavated under footings and within 18 inches (450 mm) of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Division 03 Section "Cast-in-place Concrete".
4. Trenches under Roadways: Provide 4-inch- (100-mm-) thick, concrete-base slab support for piping or conduit less than 30 inches (750 mm) below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches (100 mm) of concrete before backfilling or placing roadway subbase course. Concrete is specified in Division 03 Section "Cast-in-place Concrete".
5. Backfill voids with satisfactory soil while removing shoring and bracing.
6. If soil material is required as initial backfill, place and compact initial backfill of subbase material **OR** satisfactory soil, **as directed**, free of particles larger than 1 inch (25 mm) in any dimension, to a height of 12 inches (300 mm) over the pipe or conduit.
   a. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.
7. Controlled Low-Strength Material: If controlled low-strength material is permitted or required as initial backfill, place initial backfill of controlled low-strength material to a height of 12 inches (300 mm) over the pipe or conduit. Coordinate backfilling with utilities testing.
8. If satisfactory soil material is required as final backfill, place and compact final backfill of satisfactory soil to final subgrade elevation.
9. Controlled Low-Strength Material: If controlled low-strength material is permitted or required as final backfill, place final backfill of controlled low-strength material to final subgrade elevation.
10. Install warning tape directly above utilities, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

N. Soil Fill
1. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
2. Place and compact fill material in layers to required elevations as follows:
   a. Under grass and planted areas, use satisfactory soil material.
   b. Under walks and pavements, use satisfactory soil material.
   c. Under steps and ramps, use engineered fill.
   d. Under building slabs, use engineered fill.
   e. Under footings and foundations, use engineered fill.
3. Place soil fill on subgrades free of mud, frost, snow, or ice.

O. Geofoam Fill
1. Place a leveling course of sand, 2 inches (50 mm) thick, over subgrade. Finish leveling course to a tolerance of 1/2 inch (13 mm) when tested with a 10-foot (3-m) straightedge.
   a. Place leveling course on subgrades free of mud, frost, snow, or ice.
   b. Install geofoam blocks in layers with abutting edges and ends and with the long dimension of each block at right angles to blocks in each subsequent layer. Offset joints of blocks in successive layers.
   c. Install geofoam connectors at each layer of geofoam to resist horizontal displacement according to geofoam manufacturer's written instructions.
2. Cover geofoam with subdrainage **OR** separation, **as directed**, geotextile before placing overlying soil materials.

P. Soil Moisture Control
1. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
   a. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.

b. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

Q. Compaction Of Soil Backfills And Fills
1. Place backfill and fill soil materials in layers not more than 8 inches (200 mm) in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches (100 mm) in loose depth for material compacted by hand-operated tampers.
2. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
3. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 698 **OR** ASTM D 1557, **as directed**:
   a. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches (300 mm) of existing subgrade and each layer of backfill or fill soil material at 95 percent.
   b. Under walkways, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill soil material at 92 percent.
   c. Under turf or unpaved areas, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill soil material at 85 percent.
   d. For utility trenches, compact each layer of initial and final backfill soil material at 85 percent.

R. Grading
1. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
   a. Provide a smooth transition between adjacent existing grades and new grades.
   b. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
2. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
   a. Turf or Unpaved Areas: Plus or minus 1 inch (25 mm).
   b. Walks: Plus or minus 1 inch (25 mm).
   c. Pavements: Plus or minus 1/2 inch (13 mm).
3. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch (13 mm) when tested with a 10-foot (3-m) straightedge.

S. Subsurface Drainage
1. Subdrainage Pipe: Specified in Division 33 Section "Storm Utility Drainage Piping".
2. Subsurface Drain: If nonwoven geotextile is used in subsurface drainage applications, place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch (150-mm) course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches (300 mm) of filter material, placed in compacted layers 6 inches (150 mm) thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches (150 mm).
   a. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698 **OR** with a minimum of two passes of a plate-type vibratory compactor, **as directed**.
3. Drainage Backfill: If using free-draining granular backfill against walls, place and compact filter material over subsurface drain, in width indicated, to within 12 inches (300 mm) of final subgrade, in compacted layers 6 inches (150 mm) thick. Overlay drainage backfill with one layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches (150 mm).
   a. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698 **OR** with a minimum of two passes of a plate-type vibratory compactor, **as directed**.

b. Place and compact impervious fill over drainage backfill in 6-inch- (150-mm-) thick compacted layers to final subgrade.

T. Subbase And Base Courses Under Pavements And Walks
1. Place subbase course and base course, **as directed**, on subgrades free of mud, frost, snow, or ice.
2. On prepared subgrade, place subbase course and base course, **as directed**, under pavements and walks as follows:
   a. Install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
   b. Place base course material over subbase course under hot-mix asphalt pavement.
   c. Shape subbase course and base course, **as directed**, to required crown elevations and cross-slope grades.
   d. Place subbase course and base course, **as directed**, 6 inches (150 mm) or less in compacted thickness in a single layer.
   e. Place subbase course and base course, **as directed**, that exceeds 6 inches (150 mm) in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches (150 mm) thick or less than 3 inches (75 mm) thick.
   f. Compact subbase course and base course, **as directed**, at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 698 **OR** ASTM D 1557, **as directed**.
3. Pavement Shoulders: Place shoulders along edges of subbase course and base course, **as directed**, to prevent lateral movement. Construct shoulders, at least 12 inches (300 mm) wide, of satisfactory soil materials and compact simultaneously with each subbase and base, **as directed**, layer to not less than 95 percent of maximum dry unit weight according to ASTM D 698 **OR** ASTM D 1557, **as directed**.

U. Drainage Course Under Concrete Slabs-On-Grade
1. Place drainage course on subgrades free of mud, frost, snow, or ice.
2. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:
   a. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
   b. Place drainage course 6 inches (150 mm) or less in compacted thickness in a single layer.
   c. Place drainage course that exceeds 6 inches (150 mm) in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches (150 mm) thick or less than 3 inches (75 mm) thick.
   d. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

V. Field Quality Control
1. Special Inspections: If special inspections are required by code, engage a qualified special inspector to perform the following special inspections:
   a. Determine prior to placement of fill that site has been prepared in compliance with requirements.
   b. Determine that fill material and maximum lift thickness comply with requirements.
   c. Determine, at the required frequency, that in-place density of compacted fill complies with requirements.
2. Testing Agency: Engage a qualified geotechnical engineering testing agency to perform tests and inspections.
3. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.
4. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing

subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by the Owner.

5. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:
   a. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 sq. ft. (186 sq. m) or less of paved area or building slab, but in no case fewer than three tests.
   b. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet (30 m) or less of wall length, but no fewer than two tests.
   c. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet (46 m) or less of trench length, but no fewer than two tests.
6. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

W. Protection
1. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
2. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
   a. Scarify or remove and replace soil material to depth as directed by the Owner; reshape and recompact.
3. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
   a. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

X. Disposal Of Surplus And Waste Materials
1. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off the Owner's property.
   OR
   Transport surplus satisfactory soil to designated storage areas on the Owner's property. Stockpile or spread soil as directed by the Owner.
   a. Remove waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off the Owner's property.

END OF SECTION 31 01 20 00

SECTION 31 05 13 00 - SUBDRAINAGE

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for subdrainage. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Perforated-wall pipe and fittings.
b. Drainage conduits.
c. Drainage panels.
d. Geotextile filter fabrics.

C. Submittals
1. Drainage conduits, including rated capacities.
2. Drainage panels, including rated capacities.
3. Geotextile filter fabrics.

1.2 PRODUCTS

A. Perforated-Wall Pipes And Fittings
1. Perforated PE Pipe and Fittings:
a. NPS 6 (DN 150) and Smaller: ASTM F 405 or AASHTO M 252, Type CP; corrugated, for coupled joints.
b. NPS 8 (DN 200) and Larger: ASTM F 667; AASHTO M 252, Type CP; or AASHTO M 294, Type CP; corrugated; for coupled joints.
c. Couplings: Manufacturer's standard, band type.
2. Perforated PVC Sewer Pipe and Fittings: ASTM D 2729, bell-and-spigot ends, for loose joints.
3. Perforated Clay Pipe and Fittings: ASTM C 700, Standard- and Extra-Strength classes, unglazed, socket-and-spigot ends, for gasketed joints.
a. Gaskets: ASTM C 425, rubber.
4. Perforated Concrete Pipe and Fittings: ASTM C 444 (ASTM C 444M), Type 1, and applicable requirements in ASTM C 14 (ASTM C 14M), Class 2, socket-and-spigot ends for gasketed joints.
a. Gaskets: ASTM C 443 (ASTM C 443M), rubber.

B. Drainage Conduits
1. Molded-Sheet Drainage Conduits: Prefabricated geocomposite with cuspated, molded-plastic drainage core wrapped in geotextile filter fabric.
a. Nominal Size: 12 inches (305 mm) high by approximately 1 inch (25 mm) thick.
1) Minimum In-Plane Flow: 30 gpm (114 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
b. Nominal Size: 18 inches (457 mm) high by approximately 1 inch (25 mm) thick.
1) Minimum In-Plane Flow: 45 gpm (170 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
c. Filter Fabric: PP geotextile.
d. Fittings: HDPE with combination NPS 4 and NPS 6 (DN 100 and DN 150) outlet connection.

2. Multipipe Drainage Conduits: Prefabricated geocomposite with interconnected, corrugated, perforated-pipe core molded from HDPE complying with ASTM D 1248 and wrapped in geotextile filter fabric.
   a. Nominal Size: 6 inches (152 mm) high by approximately 1-1/4 inches (31 mm) thick.
      1) Minimum In-Plane Flow: 15 gpm (57 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
   b. Nominal Size: 12 inches (305 mm) high by approximately 1-1/4 inches (31 mm) thick.
      1) Minimum In-Plane Flow: 30 gpm (114 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
   c. Nominal Size: 18 inches (457 mm) high by approximately 1-1/4 inches (31 mm) thick.
      1) Minimum In-Plane Flow: 45 gpm (170 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
   d. Filter Fabric: Nonwoven, needle-punched geotextile.
   e. Fittings: HDPE with combination NPS 4 and NPS 6 (DN 100 and DN 150) outlet connection.
   f. Couplings: HDPE.
3. Single-Pipe Drainage Conduits: Prefabricated geocomposite with perforated corrugated core molded from HDPE complying with ASTM D 3350 and wrapped in geotextile filter fabric.
   a. Nominal Size: 12 inches (305 mm) high by approximately 1 inch (25 mm) thick.
      1) Minimum In-Plane Flow: 30 gpm (114 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
   b. Nominal Size: 18 inches (457 mm) high by approximately 1 inch (25 mm) thick.
      1) Minimum In-Plane Flow: 45 gpm (170 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
   c. Filter Fabric: Nonwoven, PP geotextile.
   d. Fittings: HDPE with combination NPS 4 and NPS 6 (DN 100 and DN 150) outlet connection.
   e. Couplings: Corrugated HDPE band.
4. Mesh Fabric Drainage Conduits: Prefabricated geocomposite with plastic-filament drainage core wrapped in geotextile filter fabric. Include fittings for bends and connection to drainage piping.
   a. Nominal Size: 6 inches (2-mm) high by approximately 0.9 inch (23 mm) thick.
      1) Minimum In-Plane Flow: 2.4 gpm (9.1 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
   b. Filter Fabric: Nonwoven geotextile made of PP or polyester fibers or combination of both. Flow rates range from 120 to 200 gpm/sq. ft. (81 to 136 L/s per sq. m) when tested according to ASTM D 4491.
5. Ring Fabric Drainage Conduits: Drainage conduit with HDPE-rings-in-grid-pattern drainage core, for field-applied geotextile filter fabric. Include fittings for bends and connection to drainage piping.
   a. Nominal Size: 18 inches (0.5 m) high by 1 inch (25 mm) thick.
      1) Minimum In-Plane Flow: 82 gpm (310 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
   b. Nominal Size: 36 inches (1 m) high by 1 inch (25 mm) thick.
      1) Minimum In-Plane Flow: 164 gpm (621 L/min.) at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
   c. Filter Fabric: Specified in Part 1.2 "Geotextile Filter Fabrics" Article.

C. Drainage Panels
1. Molded-Sheet Drainage Panels: Prefabricated geocomposite, 36 to 60 inches (915 to 1525 mm) wide with drainage core faced with geotextile filter fabric.
   a. Drainage Core: Three-dimensional, nonbiodegradable, molded PP.
      1) Minimum Compressive Strength: 10,000 lbf/sq. ft. (479 kPa) **OR** 15,000 lbf/sq. ft. (718 kPa) **OR** 18,000 lbf/sq. ft. (862 kPa) **OR** 21,000 lbf/sq. ft. (1005 kPa), **as directed**, when tested according to ASTM D 1621.

2) Minimum In-Plane Flow Rate: 2.8 gpm/ft. (35 L/min. per m) **OR** 7 gpm/ft. (87 L/min. per m) **OR** 15 gpm/ft. (188 L/min. per m), **as directed,** of unit width at hydraulic gradient of 1.0 and compressive stress of 25 psig (172 kPa) when tested according to ASTM D 4716.

b. Filter Fabric: Nonwoven needle-punched geotextile, manufactured for subsurface drainage, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with the following properties determined according to AASHTO M 288:
1) Survivability: Class 1 **OR** 2 **OR** 3, **as directed**.
2) Apparent Opening Size: No. 40 (0.425-mm) **OR** No. 60 (0.25-mm) **OR** No. 70 (0.212-mm), **as directed,** sieve, maximum.
3) Permittivity: 0.5 **OR** 0.2 **OR** 0.1, **as directed,** per second, minimum.

c. Filter Fabric: Woven geotextile fabric, manufactured for subsurface drainage, made from polyolefins or polyesters; with elongation less than 50 percent; complying with the following properties determined according to AASHTO M 288:
1) Survivability: Class 1 **OR** 2 **OR** 3, **as directed**.
2) Apparent Opening Size: No. 40 (0.425-mm) **OR** No. 60 (0.25-mm) **OR** No. 70 (0.212-mm) **OR** No. 30 (0.6-mm), **as directed,** sieve, maximum.
3) Permittivity: 0.5 **OR** 0.2 **OR** 0.1 **OR** 0.02, **as directed,** per second, minimum.

d. Film Backing: Polymeric film bonded to drainage core surface.

2. Mesh Fabric Drainage Panels: Prefabricated geocomposite with drainage core faced with geotextile filter fabric.
a. Drainage Core: Open-construction, resilient, approximately 0.4-inch- (10.2-mm-) thick, plastic-filament mesh.
1) Minimum In-Plane Flow Rate: 2.4 gpm/ft. (30 L/min. per m) of unit width at hydraulic gradient of 1.0 and normal pressure of 25 psig (172 kPa) when tested according to ASTM D 4716.
b. Filter Fabric: Nonwoven geotextile of PP or polyester fibers or combination of both. Flow rates range from 120 to 200 gpm/sq. ft. (81 to 136 L/s per sq. m) when tested according to ASTM D 4491.

3. Net Fabric Drainage Panels: Prefabricated geocomposite with drainage core faced with geotextile filter fabric.
a. Drainage Core: 3-dimensional, PE nonwoven-strand geonet, approximately 0.25-inch- (6-mm-) thick.
1) Minimum In-Plane Flow Rate: 2.4 gpm/ft. (30 L/min. per m) **OR** 5 gpm/ft. (62 L/min. per m), **as directed,** of unit width at hydraulic gradient of 1.0 and normal pressure of 25 psig (172 kPa) when tested according to ASTM D 4716.
b. Filter Fabric: Nonwoven geotextile of PP or polyester fibers or combination of both. Flow rates range from 120 to 200 gpm/sq. ft. (81 to 136 L/s per sq. m) when tested according to ASTM D 4491.

4. Ring Fabric Drainage Panels: Drainage-core panel for field application of geotextile filter fabric.
a. Drainage Core: 3-dimensional, HDPE rings in grid pattern, approximately 1 inch (25 mm) thick.
1) Minimum In-Plane Flow Rate: 40 gpm/ft. (500 L/min. per m) of unit width at hydraulic gradient of 1.0 and normal pressure of 25 psig (172 kPa) when tested according to ASTM D 4716.

5. Fabric-Covered Insulated Drainage Panels: Extruded PS board insulation complying with ASTM C 578; fabricated with shiplap **OR** tongue-and-groove, **as directed**, edges and with one side having grooved drainage channels; unfaced **OR** ; faced with geotextile filter fabric, **as directed**.
a. Type IV, 1.6-lb/cu. ft. (26-kg/cu. m) minimum density and 25-psig (172-kPa) minimum compressive strength.
b. Type VI, 1.8-lb/cu. ft. (29-kg/cu. m) minimum density and 40-psig (276-kPa) minimum compressive strength.
c. Minimum In-Plane Flow Rate: 9 gpm/ft. (112 L/min. per m) of unit width when tested according to ASTM D 4716.

d. Filter Fabric: Nonwoven geotextile of PP or polyester fibers or combination of both. Flow rates range from 120 to 200 gpm/sq. ft. (81 to 136 L/s per sq. m) when tested according to ASTM D 4491.

6. Noncovered Insulated Drainage Panels: Extruded PS board insulation complying with ASTM C 578; fabricated with rabbeted edges and with one side having ribbed drainage channels.
   a. Type VI, 1.8-lb/cu. ft. (29-kg/cu. m) minimum density and 40-psig (276-kPa) minimum compressive strength.
   b. Type VII, 2.2-lb/cu. ft. (35-kg/cu. m) minimum density and 60-psig (414-kPa) minimum compressive strength.
   c. Minimum In-Plane Flow Rate: 9 gpm/ft. (112 L/min. per m) of unit width when tested according to ASTM D 4716.
7. Expanded PS Insulated Drainage Panels: PS bead board insulation; panels are 4 inches (102 mm) thick by 48 inches (1220 mm) wide and faced with geotextile filter fabric.
   a. Density: 2 lb/cu. ft. (32 kg/cu. m).
   b. Compressive Strength: 800 lbf/sq. ft. (38 kPa).
   c. Minimum In-Plane Flow Rate: 3 gpm/ft. (37 L/min. per m) of unit width when tested according to ASTM D 4716.
   d. Filter Fabric: Nonwoven geotextile of PP or polyester fibers or combination of both. Flow rates range from 120 to 200 gpm/sq. ft. (81 to 136 L/s per sq. m) when tested according to ASTM D 4491.

D. Soil Materials
1. Soil materials are specified in Division 31 Section "Earth Moving".

E. Waterproofing Felts
1. Material: Comply with ASTM D 226, Type I, asphalt **OR** ASTM D 227, coal-tar, **as directed**,- saturated organic felt.

F. Geotextile Filter Fabrics
1. Description: Fabric of PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. (4480 to 13 440 L/min. per sq. m) when tested according to ASTM D 4491.
   a. Structure Type: Nonwoven, needle-punched continuous filament.
      1) Survivability: AASHTO **M 288 Class 2.**
      2) Style(s): Flat **OR** sock, **as directed**.

1.3 EXECUTION

A. Earthwork
1. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving".

B. Foundation Drainage Installation
1. Place impervious fill material on subgrade adjacent to bottom of footing after concrete footing forms have been removed. Place and compact impervious fill to dimensions indicated, but not less than 6 inches (150 mm) deep and 12 inches (300 mm) wide.
2. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
3. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).
4. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape.
5. Install drainage piping as indicated in Article 1.3 "Piping Installation" for foundation subdrainage.
6. Add drainage course to width of at least 6 inches (150 mm) on side away from wall and to top of pipe to perform tests.
7. After satisfactory testing, cover drainage piping to width of at least 6 inches (150 mm) on side away from footing and above top of pipe to within 12 inches (300 mm) of finish grade.

8. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.
9. Place layer of flat-style geotextile filter fabric **OR** waterproofing felt, **as directed,** over top of drainage course, overlapping edges at least 4 inches (100 mm).
10. Install drainage panels on foundation walls as follows:
    a. Coordinate placement with other drainage materials.
    b. Lay perforated drainage pipe at base of footing. Install as indicated in Article 1.3 "Piping Installation."
    c. Separate 4 inches (100 mm) of fabric at beginning of roll and cut away 4 inches (100 mm) of core. Wrap fabric around end of remaining core.
    d. Attach panels to wall beginning at subdrainage pipe. Place and secure molded-sheet drainage panels, with geotextile facing away from wall.
11. Place backfill material over compacted drainage course. Place material in loose-depth layers not exceeding 6 inches (150 mm). Thoroughly compact each layer. Final backfill to finish elevations and slope away from building.

C. Underslab Drainage Installation
1. Excavate for underslab drainage system after subgrade material has been compacted but before drainage course has been placed. Include horizontal distance of at least 6 inches (150 mm) between drainage pipe and trench walls. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.
2. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
3. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).
4. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape.
5. Install drainage piping as indicated in Part 1.3 "Piping Installation" Article for underslab subdrainage.
6. Add drainage course to width of at least 6 inches (150 mm) on side away from wall and to top of pipe to perform tests.
7. After satisfactory testing, cover drainage piping with drainage course to elevation of bottom of slab, and compact and wrap top of drainage course with flat-style geotextile filter fabric.
8. Install horizontal drainage panels as follows:
    a. Coordinate placement with other drainage materials.
    b. Lay perforated drainage pipe at inside edge of footings.
    c. Place drainage panel over drainage pipe with core side up. Peel back fabric and wrap fabric around pipe. Locate top of core at bottom elevation of floor slab.
    d. Butt additional panels against other installed panels. If panels have plastic flanges, overlap installed panel with flange.

D. Retaining-Wall Drainage Installation
1. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
2. Place supporting layer of drainage course over compacted subgrade to compacted depth of not less than 4 inches (100 mm).
3. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape.
4. Install drainage piping as indicated in Article 1.3 "Piping Installation" for retaining-wall subdrainage.
5. Add drainage course to width of at least 6 inches (150 mm) on side away from wall and to top of pipe to perform tests.
6. After satisfactory testing, cover drainage piping to width of at least 6 inches (150 mm) on side away from footing and above top of pipe to within 12 inches (300 mm) of finish grade.
7. Place drainage course in layers not exceeding 3 inches (75 mm) in loose depth; compact each layer placed and wrap top of drainage course with flat-style geotextile filter fabric.
8. Place layer of flat-style geotextile filter fabric **OR** waterproofing felt, **as directed,** over top of drainage course, overlapping edges at least 4 inches (100 mm).
9. Install drainage panels on walls as follows:

a. Coordinate placement with other drainage materials.
b. Lay perforated drainage pipe at base of footing as described elsewhere in this Specification. Do not install aggregate.
c. If weep holes are used instead of drainage pipe, cut 1/2-inch- (13-mm-) diameter holes on core side at weep-hole locations. Do not cut fabric.
d. Mark horizontal calk line on wall at a point 6 inches (150 mm) less than panel width above footing bottom. Before marking wall, subtract footing width.
e. Separate 4 inches (100 mm) of fabric at beginning of roll and cut away 4 inches (100 mm) of core. Wrap fabric around end of remaining core.
f. Attach panel to wall at horizontal mark and at beginning of wall corner. Place core side of panel against wall. Use concrete nails with washers through product. Place nails from 2 to 6 inches (50 to 150 mm) below top of panel, approximately 48 inches (1200 mm) apart. Construction adhesives, metal stick pins, or double-sided tape may be used instead of nails. Do not penetrate waterproofing. Before using adhesives, discuss with waterproofing manufacturer.
g. If another panel is required on same row, cut away 4 inches (100 mm) of installed panel core and wrap fabric over new panel.
h. If additional rows of panel are required, overlap lower panel with 4 inches (100 mm) of fabric.
i. Cut panel as necessary to keep top 12 inches (300 mm) below finish grade.
j. For inside corners, bend panel. For outside corners, cut core to provide 3 inches (75 mm) for overlap.

10. Fill to Grade: Place satisfactory soil fill material over compacted drainage course . Place material in loose-depth layers not exceeding 6 inches (150 mm). Thoroughly compact each layer. Fill to finish grade.

E. Landscaping Drainage Installation
1. Provide trench width to allow installation of drainage conduit. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.
2. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
3. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).
4. Install drainage conduits as indicated in Article 1.3 "Piping Installation" for landscaping subdrainage with horizontal distance of at least 6 inches (150 mm) between conduit and trench walls. Wrap drainage conduits without integral geotextile filter fabric with flat-style geotextile filter fabric before installation. Connect fabric sections with adhesive or tape.
5. Add drainage course to top of drainage conduits.
6. After satisfactory testing, cover drainage conduit to within 12 inches (300 mm) of finish grade.
7. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.
8. Place layer of flat-style geotextile filter fabric **OR** waterproofing felt, **as directed,** over top of drainage course, overlapping edges at least 4 inches (100 mm).
9. Fill to Grade: Place satisfactory soil fill material over drainage course. Place material in loose-depth layers not exceeding 6 inches (150 mm). Thoroughly compact each layer. Fill to finish grade.

F. Piping Installation
1. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions and other requirements indicated.
a. Foundation Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 0.5 percent and with a minimum cover of 36 inches (915 mm), unless otherwise indicated.
b. Underslab Subdrainage: Install piping level.
c. Plaza Deck Subdrainage: Install piping level.

d. Retaining-Wall Subdrainage: When water discharges at end of wall into stormwater piping system, install piping level and with a minimum cover of 36 inches (915 mm), unless otherwise indicated.
e. Landscaping Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 0.5 percent and with a minimum cover of 36 inches (915 mm), unless otherwise indicated.
f. Lay perforated pipe with perforations down.
g. Excavate recesses in trench bottom for bell ends of pipe. Lay pipe with bells facing upslope and with spigot end entered fully into adjacent bell.

2. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.
3. Install thermoplastic piping according to ASTM D 2321.

G. Pipe Joint Construction
1. Join perforated PE pipe and fittings with couplings according to ASTM D 3212 with loose banded, coupled, or push-on joints.
2. Join perforated PVC sewer pipe and fittings according to ASTM D 3212 with loose bell-and-spigot, push-on joints.
3. Special Pipe Couplings: Join piping made of different materials and dimensions with special couplings made for this application. Use couplings that are compatible with and fit materials and dimensions of both pipes.

1.4 Backwater Valve Installation
1. Comply with requirements for backwater valves specified in Division 2 Section "Storm Drainage."
2. Install horizontal backwater valves in header piping downstream from perforated subdrainage piping.
3. Install horizontal backwater valves in piping in manholes or pits where indicated.

B. Cleanout Installation
1. Comply with requirements for cleanouts specified in Division 2 Section "Storm Drainage."
2. Cleanouts for Foundation, Retaining-Wall, and Landscaping Subdrainage:
a. Install cleanouts from piping to grade. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
b. In vehicular-traffic areas, use NPS 4 (DN 100) cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, 18 by 18 by 12 inches (450 by 450 by 300 mm) in depth. Set top of cleanout flush with grade. Cast-iron pipe may also be used for cleanouts in nonvehicular-traffic areas.
c. In nonvehicular-traffic areas, use NPS 4 (DN 100) cast-iron **OR** PVC, **as directed,** pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, 12 by 12 by 4 inches (300 by 300 by 100 mm) in depth. Set top of cleanout plug 1 inch (25 mm) above grade.
3. Cleanouts for Underslab Subdrainage:
a. Install cleanouts and riser extensions from piping to top of slab. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
b. Use NPS 4 (DN 100) cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout flush with top of slab.

C. Connections
1. Comply with requirements for piping specified in Division 2 Section "Storm Drainage." Drawings indicate general arrangement of piping, fittings, and specialties.
2. Connect low elevations of subdrainage system to building's solid-wall-piping storm drainage system.

3. Where required, connect low elevations of foundation **OR** Underslab, **as directed,** subdrainage to stormwater sump pumps.

D. Identification
   1. Arrange for installation of green warning tapes directly over piping. Comply with requirements for underground warning tapes specified in specified in Division 31 Section "Earth Moving".
      a. Install PE warning tape or detectable warning tape over ferrous piping.
      b. Install detectable warning tape over nonferrous piping and over edges of underground structures.

E. Field Quality Control
   1. Tests and Inspections:
      a. After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling.
      b. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.
   2. Drain piping will be considered defective if it does not pass tests and inspections.
   3. Prepare test and inspection reports.

F. Cleaning
   1. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

END OF SECTION 31 05 13 00

Task	Specification	Specification Description
31 05 13 00	31 01 20 00	Earthwork
31 05 16 00	31 01 20 00	Earthwork
31 05 16 00	31 05 13 00	Subdrainage

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SECTION 31 11 00 00 - SITE CLEARING

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for site clearing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
   a. Protecting existing vegetation to remain.
   b. Removing existing vegetation.
   c. Clearing and grubbing.
   d. Stripping and stockpiling topsoil.
   e. Removing above- and below-grade site improvements.
   f. Disconnecting, capping or sealing, and removing site utilities **OR** abandoning site utilities in place, **as directed**.
   g. Temporary erosion- and sedimentation-control measures.

C. Definitions

1. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
   OR
   Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.
2. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow.
   OR
   Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches (50 mm) in diameter; and free of subsoil and weeds, roots, toxic materials, or other nonsoil materials.
3. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction, and indicated on Drawings.
   OR
   Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and indicated on Drawings **OR** defined by a circle concentric with each tree with a radius 1.5 times the diameter of the drip line unless otherwise indicated, **as directed**.
4. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

D. Material Ownership

1. Except for stripped topsoil and other materials indicated to be stockpiled or otherwise remain the Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

E. Submittals

1. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.
   a. Use sufficiently detailed photographs or videotape.

b. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plants designated to remain.

2. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

F. Quality Assurance

1. Preinstallation Conference: Conduct conference at Project site.

G. Project Conditions

1. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
   a. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the Owner and authorities having jurisdiction.
   b. Provide alternate routes around closed or obstructed traffic ways if required by the Owner or authorities having jurisdiction.
2. Improvements on Adjoining Property: Authority for performing site clearing indicated on property adjoining the Owner's property will be obtained by the Owner before award of Contract.
   a. Do not proceed with work on adjoining property until directed by the Owner.
3. Salvable Improvements: Carefully remove items indicated to be salvaged and store on the Owner's premises where indicated.
4. Utility Locator Service: Notify utility locator service **OR** Miss Utility **OR** Call Before You Dig **OR** Dig Safe System **OR** One Call, **as directed**, for area where Project is located before site clearing.
5. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant-protection measures are in place.
6. The following practices are prohibited within protection zones:
   a. Storage of construction materials, debris, or excavated material.
   b. Parking vehicles or equipment.
   c. Foot traffic.
   d. Erection of sheds or structures.
   e. Impoundment of water.
   f. Excavation or other digging unless otherwise indicated.
   g. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
7. Do not direct vehicle or equipment exhaust towards protection zones.
8. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.
9. Soil Stripping, Handling, and Stockpiling: Perform only when the topsoil is dry or slightly moist.

1.2 PRODUCTS

A. Materials

1. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Division 31 Section "Earth Moving".
   a. If soil backfill is required in below-grade areas after site clearing, obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.
2. Antirust Coating: Fast-curing, lead- and chromate-free, self-curing, universal modified-alkyd primer complying with MPI #79, Alkyd Anticorrosive Metal Primer **OR** SSPC-Paint 20 or SSPC-Paint 29 zinc-rich coating, **as directed**.
   a. Use coating with a VOC content of 420 g/L (3.5 lb/gal.) or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

1.3 EXECUTION

A. Preparation

1. Protect and maintain benchmarks and survey control points from disturbance during construction.
2. Locate and clearly identify trees, shrubs, and other vegetation to remain or to be relocated. Flag **OR** Wrap a 1-inch (25-mm) blue vinyl tie tape flag around, **as directed**, each tree trunk at 54 inches (1372 mm) above the ground.
3. Protect existing site improvements to remain from damage during construction.
   a. Restore damaged improvements to their original condition, as acceptable to the Owner.

B. Temporary Erosion And Sedimentation Control
1. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of authorities having jurisdiction.
2. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.
3. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.
4. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

C. Tree And Plant Protection
1. General: Protect trees and plants remaining on-site according to requirements in Division 01 Section "Temporary Tree And Plant Protection".
2. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner approved by the Owner.

D. Existing Utilities
1. the Owner will arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing, when requested by Contractor.
   OR
   Verify that utilities have been disconnected and capped before proceeding with site clearing.
2. Locate, identify, disconnect, and seal or cap utilities indicated to be removed.
   a. Arrange with utility companies to shut off indicated utilities.
      OR
      the Owner will arrange to shut off indicated utilities when requested by Contractor.
3. Locate, identify, and disconnect utilities indicated to be abandoned in place.
4. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
   a. Notify the Owner not less than two days in advance of proposed utility interruptions.
   b. Do not proceed with utility interruptions without the Owner 's written permission.
5. Excavate for and remove underground utilities indicated to be removed.
   OR
   Removal of underground utilities is included in Division 21 OR Division 22 OR Division 23 OR Division 26 OR Division 28.

E. Clearing And Grubbing
1. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.
   a. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
   b. Grind down stumps and remove roots, obstructions, and debris to a depth of 18 inches (450 mm) below exposed subgrade.
   c. Use only hand methods for grubbing within protection zones.
   d. Chip removed tree branches and stockpile in areas approved by the Owner **OR** dispose of off-site, **as directed**.
2. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

a. Place fill material in horizontal layers not exceeding a loose depth of 8 inches (200 mm), and compact each layer to a density equal to adjacent original ground.

F. Topsoil Stripping
1. Remove sod and grass before stripping topsoil.
2. Strip topsoil to depth indicated on Drawings **OR** to depth of 6 inches (150 mm), **as directed**, in a manner to prevent intermingling with underlying subsoil or other waste materials.
   a. Remove subsoil and nonsoil materials from topsoil, including clay lumps, gravel, and other objects more than 2 inches (50 mm) in diameter; trash, debris, weeds, roots, and other waste materials.
3. Stockpile topsoil away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.
   a. Limit height of topsoil stockpiles to 72 inches (1800 mm).
   b. Do not stockpile topsoil within protection zones.
   c. Dispose of surplus topsoil. Surplus topsoil is that which exceeds quantity indicated to be stockpiled or reused.
   d. Stockpile surplus topsoil to allow for respreading deeper topsoil.

G. Site Improvements
1. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.
2. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
   a. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically.
   b. Paint cut ends of steel reinforcement in concrete to remain with two coats of antirust coating, following coating manufacturer's written instructions. Keep paint off surfaces that will remain exposed.

H. Disposal Of Surplus And Waste Materials
1. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off the Owner's property.
2. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION 31 11 00 00

SECTION 31 13 13 00 - TREE PROTECTION AND TRIMMING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for tree protection and trimming. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes general protection and pruning of existing trees and plants that are affected by execution of the Work, whether temporary or permanent construction.

C. Definitions
1. Caliper: Diameter of a trunk measured by a diameter tape or the average of the smallest and largest diameters at 6 inches (150 mm) above the ground for trees up to, and including, 4-inch (100-mm) size; and 12 inches (300 mm) above the ground for trees larger than 4-inch (100-mm) size.
2. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction, and indicated on Drawings.
3. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and indicated on Drawings **OR** defined by a circle concentric with each tree with a radius 1.5 times the diameter of the drip line unless otherwise indicated, **as directed**.
4. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

D. Submittals
1. Product Data: For each type of product indicated.
2. Tree Pruning Schedule: Written schedule detailing scope and extent of pruning of trees to remain that interfere with or are affected by construction.
3. Qualification Data: For qualified arborist and tree service firm.
4. Certification: From arborist, certifying that trees indicated to remain have been protected during construction according to recognized standards and that trees were promptly and properly treated and repaired when damaged.
5. Maintenance Recommendations: From arborist, for care and protection of trees affected by construction during and after completing the Work.
6. Existing Conditions: Documentation of existing trees and plantings indicated to remain, which establishes preconstruction conditions that might be misconstrued as damage caused by construction activities.
   a. Use sufficiently detailed photographs or videotape.
   b. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plants designated to remain.

E. Quality Assurance
1. Arborist Qualifications: Certified Arborist as certified by ISA **OR** Certified Arborist-Municipal Specialist as certified by ISA **OR** Licensed arborist in jurisdiction where Project is located **OR** Current member of ASCA **OR** Registered Consulting Arborist as designated by ASCA, **as directed**.
2. Tree Service Firm Qualifications: An experienced tree service firm that has successfully completed temporary tree and plant protection work similar to that required for this Project and that will assign an experienced, qualified arborist to Project site during execution of the Work.
3. Preinstallation Conference: Conduct conference at Project site.

F. Project Conditions

1. The following practices are prohibited within protection zones:
   a. Storage of construction materials, debris, or excavated material.
   b. Parking vehicles or equipment.
   c. Foot traffic.
   d. Erection of sheds or structures.
   e. Impoundment of water.
   f. Excavation or other digging unless otherwise indicated.
   g. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
2. Do not direct vehicle or equipment exhaust toward protection zones.
3. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones and organic mulch.

1.2 PRODUCTS

A. Materials

1. Topsoil: Natural or cultivated top layer of the soil profile or manufactured topsoil; containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 1 inch (25 mm) in diameter; and free of weeds, roots, and toxic and other nonsoil materials.
   a. Obtain topsoil only from well-drained sites where topsoil is 4 inches (100 mm) deep or more; do not obtain from bogs or marshes.

   OR

   Topsoil: Stockpiled topsoil from location shown on Drawings **OR** Imported or manufactured topsoil complying with ASTM D 5268, **as directed**.
2. Organic Mulch: Free from deleterious materials and suitable as a top dressing for trees and shrubs, consisting of one of the following:
   a. Type: Shredded hardwood **OR** Ground or shredded bark **OR** Wood and bark chips, **as directed**.
   b. Size Range: 3 inches (76 mm) maximum, 1/2 inch (13 mm) minimum.
3. Protection-Zone Fencing: Fencing fixed in position and meeting one of the following requirements, **as directed**. Previously used materials may be used when approved by the Owner.
   a. Chain-Link Protection-Zone Fencing: Galvanized-steel **OR** Polymer-coated steel **OR** Polymer-coated galvanized-steel, **as directed**, fencing fabricated from minimum 2-inch (50-mm) opening, 0.148-inch- (3.76-mm-) diameter wire chain-link fabric; with pipe posts, minimum 2-3/8-inch- (60-mm-) OD line posts, and 2-7/8-inch- (73-mm-) OD corner and pull posts; with 1-5/8-inch- (42-mm-) OD top rails **OR** with 0.177-inch- (4.5-mm-) diameter top tension wire, **as directed**, and 0.177-inch- (4.5-mm-) diameter bottom tension wire; with tie wires, hog ring ties, and other accessories for a complete fence system.
      1) Height: 4 feet (1.2 m) **OR** 6 feet (1.8 m) **OR** 8 feet (2.4 m), **as directed**.
      2) Polymer-Coating Color (if polymer coating is required): Dark green **OR** Olive green **OR** Brown **OR** Black, **as directed**.
   b. Plywood Protection-Zone Fencing: Plywood framed with four 2-by-4-inch (50-by-100-mm) rails, with 4-by-4-inch (100-by-100-mm) preservative-treated wood posts spaced not more than 8 feet (2.4 m) apart.
      1) Height: 4 feet (1.2 m) **OR** 6 feet (1.8 m), **as directed**.
      2) Plywood and Lumber: Comply with requirements in Division 06 Section "Rough Carpentry" **OR** Division 06 Section "Miscellaneous Rough Carpentry", **as directed**.
   c. Wood Protection-Zone Fencing: Constructed of two 2-by-4-inch (50-by-100-mm) horizontal rails, with 4-by-4-inch (100-by-100-mm) preservative-treated wood posts spaced not more than 8 feet (2.4 m) apart, and lower rail set halfway between top rail and ground.
      1) Height: 4 feet (1.2 m).

2) Lumber: Comply with requirements in Division 06 Section "Rough Carpentry" **OR** Division 06 Section "Miscellaneous Rough Carpentry", **as directed**.

d. Plastic Protection-Zone Fencing: Plastic construction fencing constructed of high-density extruded and stretched polyethylene fabric with 2-inch (50-mm) maximum opening in pattern and weighing a minimum of 0.4 lb/ft. (0.6 kg/m); remaining flexible from minus 60 to plus 200 deg F (minus 16 to plus 93 deg C); inert to most chemicals and acids; minimum tensile yield strength of 2000 psi (13.8 MPa) and ultimate tensile strength of 2680 psi (18.5 MPa); secured with plastic bands or galvanized-steel or stainless-steel wire ties; and supported by tubular or T-shape galvanized-steel posts spaced not more than 8 feet (2.4 m) apart.
1) Height: 4 feet (1.2 m).
2) Color: High-visibility orange, nonfading.

e. Gates: Single **OR** Double, **as directed**, swing access gates matching material and appearance of fencing, to allow for maintenance activities within protection zones; leaf width 24 inches (610 mm) **OR** 36 inches (914 mm) **OR** As indicated, **as directed**.

4. Protection-Zone Signage: Shop-fabricated, rigid plastic or metal sheet with attachment holes prepunched and reinforced; legibly printed with nonfading lettering and as follows:
a. Size and Text: As shown on Drawings.
b. Lettering: 3-inch- (75-mm-) high minimum, white **OR** black, **as directed**, characters on white **OR** red, **as directed**, background.

1.3 EXECUTION

A. Examination

1. Erosion and Sedimentation Control: Examine the site to verify that temporary erosion- and sedimentation-control measures are in place. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.
2. For the record, prepare written report, endorsed by arborist, listing conditions detrimental to tree and plant protection.

B. Preparation

1. Locate and clearly identify trees, shrubs, and other vegetation to remain or to be relocated. Flag **OR** Tie a 1-inch (25-mm) blue-vinyl tape around, **as directed**, each tree trunk at 54 inches (1372 mm) above the ground.
2. Protect tree root systems from damage caused by runoff or spillage of noxious materials while mixing, placing, or storing construction materials. Protect root systems from ponding, eroding, or excessive wetting caused by dewatering operations.
3. Tree-Protection Zones: Mulch areas inside tree-protection zones and other areas indicated.
a. Apply 4-inch (100-mm) **OR** 6-inch (150-mm), **as directed**, average thickness of organic mulch. Do not place mulch within 6 inches (150 mm) of tree trunks.

C. Tree- And Plant-Protection Zones

1. Protection-Zone Fencing: Install protection-zone fencing along edges of protection zones before materials or equipment are brought on the site and construction operations begin in a manner that will prevent people and animals from easily entering protected area except by entrance gates. Construct fencing so as not to obstruct safe passage or visibility at vehicle intersections where fencing is located adjacent to pedestrian walkways or in close proximity to street intersections, drives, or other vehicular circulation.
a. Chain-Link Fencing: Install to comply with ASTM F 567 and with manufacturer's written instructions.
b. Posts: Set or drive posts into ground one-third the total height of the fence without concrete footings. Where a post is located on existing paving or concrete to remain, provide appropriate means of post support acceptable to the Owner.
c. Access Gates: Install where indicated; adjust to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption,

or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

2. Protection-Zone Signage: Install protection-zone signage in visibly prominent locations in a manner approved by the Owner. Install one sign spaced approximately every 20 feet (6 m) **OR** 35 feet (10.5 m) **OR** 50 feet (15 m), **as directed**, on protection-zone fencing, but no fewer than four signs with each facing a different direction.
3. Maintain protection zones free of weeds and trash.
4. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner approved by the Owner.
5. Maintain protection-zone fencing and signage in good condition as acceptable to the Owner and remove when construction operations are complete and equipment has been removed from the site.
   a. Do not remove protection-zone fencing, even temporarily, to allow deliveries or equipment access through the protection zone.
   b. Temporary access is permitted subject to preapproval in writing by arborist if a root buffer effective against soil compaction is constructed as directed by arborist. Maintain root buffer so long as access is permitted.

D. Excavation
1. General: Excavate at edge of protection zones and for trenches indicated within protection zones according to requirements in Division 31 Section "Earth Moving".
2. Trenching near Trees: Where utility trenches are required within protection zones, hand excavate under or around tree roots or tunnel under the roots by drilling, auger boring, or pipe jacking. Do not cut main lateral tree roots or taproots; cut only smaller roots that interfere with installation of utilities. Cut roots as required for root pruning.
3. Redirect roots in backfill areas where possible. If encountering large, main lateral roots, expose roots beyond excavation limits as required to bend and redirect them without breaking. If encountered immediately adjacent to location of new construction and redirection is not practical, cut roots approximately 3 inches (75 mm) back from new construction and as required for root pruning.
4. Do not allow exposed roots to dry out before placing permanent backfill. Provide temporary earth cover or pack with peat moss and wrap with burlap. Water and maintain in a moist condition. Temporarily support and protect roots from damage until they are permanently relocated and covered with soil.

E. Root Pruning
1. Prune roots that are affected by temporary and permanent construction. Prune roots as follows:
   a. Cut roots manually by digging a trench and cutting exposed roots with sharp pruning instruments; do not break, tear, chop, or slant the cuts. Do not use a backhoe or other equipment that rips, tears, or pulls roots.
   b. Cut Ends: Do not paint cut root ends **OR** Coat cut ends of roots more than 1-1/2 inches (38 mm) in diameter with an emulsified asphalt or other coating formulated for use on damaged plant tissues and that is acceptable to arborist, **as directed**.
   c. Temporarily support and protect roots from damage until they are permanently redirected and covered with soil.
   d. Cover exposed roots with burlap and water regularly.
   e. Backfill as soon as possible according to requirements in Division 31 Section "Earth Moving".
2. Root Pruning at Edge of Protection Zone: Prune roots 12 inches (300 mm) outside **OR** 12 inches (300 mm) inside **OR** 6 inches (150 mm) outside **OR** 6 inches (150 mm) inside **OR** flush with the edge, **as directed**, of the protection zone, by cleanly cutting all roots to the depth of the required excavation.
3. Root Pruning within Protection Zone: Clear and excavate by hand to the depth of the required excavation to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.

F. Crown Pruning
1. Prune branches that are affected by temporary and permanent construction. Prune branches as follows:
   a. Prune trees to remain to compensate for root loss caused by damaging or cutting root system. Provide subsequent maintenance during Contract period as recommended by arborist.
   b. Pruning Standards: Prune trees according to ANSI A300 (Part 1) and the following:
      1) Type of Pruning: Cleaning **OR** Thinning **OR** Raising **OR** Reduction, **as directed**.
      2) Specialty Pruning: Restoration **OR** Vista **OR** Palm **OR** Utility, **as directed**.
   c. Cut branches with sharp pruning instruments; do not break or chop.
   d. Do not apply pruning paint to wounds.
2. Chip removed branches and spread over areas identified by the Owner **OR** stockpile in areas approved by the Owner **OR** dispose of off-site, **as directed**.

G. Regrading
1. Lowering Grade: Where new finish grade is indicated below existing grade around trees, slope grade beyond the protection zone. Maintain existing grades within the protection zone.
   OR
   Lowering Grade within Protection Zone: Where new finish grade is indicated below existing grade around trees, slope grade away from trees as recommended by arborist unless otherwise indicated.
   a. Root Pruning: Prune tree roots exposed by lowering the grade. Do not cut main lateral roots or taproots; cut only smaller roots. Cut roots as required for root pruning.
2. Raising Grade: Where new finish grade is indicated above existing grade around trees, slope grade beyond the protection zone. Maintain existing grades within the protection zone.
   OR
   Minor Fill within Protection Zone: Where existing grade is 2 inches (50 mm) or less below elevation of finish grade, fill with topsoil. Place topsoil in a single uncompacted layer and hand grade to required finish elevations.

H. Field Quality Control
1. Inspections: Engage a qualified arborist to direct plant-protection measures in the vicinity of trees, shrubs, and other vegetation indicated to remain and to prepare inspection reports.

I. Repair And Replacement
1. General: Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner approved by the Owner.
   a. Submit details of proposed root cutting and tree and shrub repairs.
   b. Have arborist perform the root cutting, branch pruning, and damage repair of trees and shrubs.
   c. Treat damaged trunks, limbs, and roots according to arborist's written instructions.
   d. Perform repairs within 24 hours.
   e. Replace vegetation that cannot be repaired and restored to full-growth status, as determined by the Owner.
2. Trees: Remove and replace trees indicated to remain that are more than 25 **OR** 66, **as directed**, percent dead or in an unhealthy condition before the end of the corrections period or are damaged during construction operations that the Owner determines are incapable of restoring to normal growth pattern.
   a. Provide new trees of same size and species as those being replaced for each tree that measures 6 inches (150 mm) **OR** 4 inches (100 mm), **as directed**, or smaller in caliper size.
      OR
      Provide one **OR** two, **as directed**, new tree(s) of 6-inch (150-mm) **OR** 4-inch (100-mm), **as directed**, caliper size for each tree being replaced that measures more than 6 inches (150 mm) **OR** 4 inches (100 mm), **as directed**, in caliper size.
      1) Species: Species selected by the Owner.

b. Plant and maintain new trees as specified in Division 32 Section "Plants".

3. Soil Aeration: Where directed by the Owner, aerate surface soil compacted during construction. Aerate 10 feet (3 m) beyond drip line and no closer than 36 inches (900 mm) to tree trunk. Drill 2-inch- (50-mm-) diameter holes a minimum of 12 inches (300 mm) deep at 24 inches (600 mm) o.c. Backfill holes with an equal mix of augered soil and sand.

J. Disposal Of Surplus And Waste Materials

1. Disposal: Remove excess excavated material, displaced trees, trash and debris, and legally dispose of them off Owner's property.

END OF SECTION 31 13 13 00

Task	Specification	Specification Description
31 13 13 00	31 11 00 00	Site Clearing
31 13 16 00	31 11 00 00	Site Clearing
31 13 16 00	31 13 13 00	Tree Protection And Trimming

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SECTION 31 23 16 13 - EXCAVATION SUPPORT AND PROTECTION

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for excavation support and protection. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Performance Requirements
1. Design, **as directed**, furnish, install, monitor, and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting soil and hydrostatic pressure and superimposed and construction loads.
   a. Delegated Design: Design excavation support and protection system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
   b. Prevent surface water from entering excavations by grading, dikes, or other means.
   c. Install excavation support and protection systems without damaging existing buildings, structures, and site improvements adjacent to excavation.
   d. Monitor vibrations, settlements, and movements.

C. Submittals
1. Shop Drawings: For excavation support and protection system.
2. Delegated-Design Submittal: For excavation support and protection system indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

D. Quality Assurance
1. Preinstallation Conference: Conduct conference at Project site.

E. Project Conditions
1. Interruption of Existing Utilities: Do not interrupt any utility serving facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
   a. Notify the Owner no fewer than two days in advance of proposed interruption of utility.
   b. Do not proceed with interruption of utility without the Owner's written permission.
2. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.
   a. During installation of excavation support and protection systems, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify the Owner if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

1.2 PRODUCTS

A. Materials
1. General: Provide materials that are either new or in serviceable condition.
2. Structural Steel: ASTM A 36/A 36M, ASTM A 690/A 690M, or ASTM A 992/A 992M.
3. Steel Sheet Piling: ASTM A 328/A 328M, ASTM A 572/A 572M, or ASTM A 690/A 690M; with continuous interlocks.

a. Corners: Site-fabricated mechanical interlock **OR** Roll-formed corner shape with continuous interlock, **as directed**.

4. Wood Lagging: Lumber, mixed hardwood, nominal rough thickness of size and strength required for application, **OR** 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**.
5. Shotcrete: Comply with Division 03 Section "Shotcrete" for shotcrete materials and mixes, reinforcement, and shotcrete application.
6. Cast-in-Place Concrete: ACI 301, of compressive strength required for application.
7. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.
8. Tiebacks: Steel bars, ASTM A 722/A 722M.
9. Tiebacks: Steel strand, ASTM A 416/A 416M.

1.3 EXECUTION

A. Preparation
1. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.
   a. Shore, support, and protect utilities encountered.
2. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
   a. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
3. Locate excavation support and protection systems clear of permanent construction so that forming and finishing of concrete surfaces are not impeded.
4. Monitor excavation support and protection systems daily during excavation progress and for as long as excavation remains open. Promptly correct bulges, breakage, or other evidence of movement to ensure that excavation support and protection systems remain stable.
5. Promptly repair damages to adjacent facilities caused by installing excavation support and protection systems.

B. Soldier Piles And Lagging
1. Install steel soldier piles before starting excavation. Extend soldier piles below excavation grade level to depths adequate to prevent lateral movement. Space soldier piles at regular intervals not to exceed allowable flexural strength of wood lagging. Accurately align exposed faces of flanges to vary not more than 2 inches (50 mm) from a horizontal line and not more than 1:120 out of vertical alignment.
2. Install wood lagging within flanges of soldier piles as excavation proceeds. Trim excavation as required to install lagging. Fill voids behind lagging with soil, and compact.
3. Install wales horizontally at locations indicated on Drawings and secure to soldier piles.

C. Sheet Piling
1. Before starting excavation, install one-piece sheet piling lengths and tightly interlock to form a continuous barrier. Accurately place the piling, using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer. Limit vertical offset of adjacent sheet piling to 60 inches (1500 mm). Accurately align exposed faces of sheet piling to vary not more than 2 inches (50 mm) from a horizontal line and not more than 1:120 out of vertical alignment. Cut tops of sheet piling to uniform elevation at top of excavation.

D. Tiebacks
1. Tiebacks: Drill, install, grout, and tension tiebacks. Test load-carrying capacity of each tieback and replace and retest deficient tiebacks.
   a. Test loading shall be observed by a qualified professional engineer responsible for design of excavation support and protection system.

b. Maintain tiebacks in place until permanent construction is able to withstand lateral soil and hydrostatic pressures.

E. Bracing
1. Bracing: Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.
   a. Do not place bracing where it will be cast into or included in permanent concrete work unless otherwise approved by the Owner.
   b. Install internal bracing, if required, to prevent spreading or distortion of braced frames.
   c. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

F. Removal And Repairs
1. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and bear soil and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils or damaging structures, pavements, facilities, and utilities.
   a. Remove excavation support and protection systems to a minimum depth of 48 inches (1200 mm) below overlaying construction and abandon remainder.
   b. Fill voids immediately with approved backfill compacted to density specified in Division 31 Section "Earth Moving".
   c. Repair or replace, as approved by the Owner, adjacent work damaged or displaced by removing excavation support and protection systems.
2. Leave excavation support and protection systems permanently in place.

END OF SECTION 31 23 16 13

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Task	Specification	Specification Description
31 23 16 13	31 01 20 00	Earthwork

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SECTION 31 23 16 26 - EMBANKMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers the reuse of suitable excavated material or furnishing material at the Contractor's expense to construct embankments where and as required by the Owner.

B. Submittals
1. Preconstruction Submittals
a. Construction equipment list.
b. Contractor shall record Existing Conditions prior to starting work in accordance with the paragraph entitled, "Existing Conditions," of this section.
c. Location of Utilities
d. Location of Tests
e. Location of Inspection
f. Location of Approved Utilities
g. A protection plan verifying the Existing Utilities left in place.
2. Test Reports for Soil Test within three working days of test date. Soil test shall comply with paragraph entitled, "Quality Control Testing During Construction."
3. Certificates of compliance for Proposed Soil Materials shall be submitted in accordance with paragraph entitled, "Tests for Proposed Soil Materials."

C. Definitions
1. Soil Materials
a. Cohesionless soil materials include gravels, gravel-sand mixtures, sands, and gravelly sands. Moisture-density relations of compacted cohesionless soils when plotted on graphs will show straight lines or reverse-shaped moisture-density curves.
b. Cohesive soil materials include clayey and silty gravels, sand-clay mixtures, gravel-silt mixtures, clayey and silty sands, sand-silt mixtures, clays, silts, and very fine sands. Moisture density relations of compacted cohesive soils when plotted on graphs will show normal moisture-density curves.
2. Subgrade shall mean the top surface of a backfill or fill or the uppermost surface of an excavation, graded to conform to the required subgrade elevation and compacted to densities indicated.
3. Degree of compaction required is expressed as a percentage of the maximum density obtained by the test procedure in AASHTO T 180, Method B or D.
4. Classified Excavation: Separate consideration will be given to the nature of the materials excavated, in accordance with the following designations and classifications.
a. Rock excavation shall include blasting, excavating, grading, and disposing of material classified as rock and shall include the satisfactory removal and disposition of boulders 1/2-cu yd (0.4 cu m) or more in volume; solid rock; rock material in ledges, bedded deposits, and unstratified masses which cannot be removed without systematic drilling and blasting; and conglomerate deposits that are so firmly cemented as to possess the characteristics of solid rock that is impossible to remove without systematic drilling and blasting. The removal of any concrete or masonry structures, except pavements, exceeding 1/2-cu yd (0.4 cu m) in volume that may be encountered in the work shall be included in this classification.
b. Common excavation shall include the satisfactory removal and disposition of materials not classified as rock excavation.
5. Unclassified Excavation: No consideration will be given to the nature of the materials, and all excavation will be designated as unclassified excavation.

D. Sampling And Testing

1. Soil Test and Inspection Service: Soil survey for satisfactory soil materials and samples of soil materials shall be furnished by the Contractor. A certified soil testing service approved by the Owner shall be provided by the Contractor. Testing shall include soil survey for satisfactory soil materials, sampling and testing soil materials proposed for use in the work, and field-testing facilities for quality control during construction period.
2. Tests for Proposed Soil Materials: Soil materials proposed for use in the work shall be tested. The materials shall be approved by the Owner prior to start of work as follows:

MATERIAL	REQUIREMENT	TEST METHOD	NUMBER OF TESTS
Satisfactory soil materials	Sampling	AASHTO T 2	One for each source of materials to determine conformance to definition of satisfactory soil materials; additional tests whenever there is any apparent change
	Preparation of samples	AASHTO T 87	
	Sieve analysis of fine and coarse aggregate	ASTM C 136	
	Mechanical analysis of soils	ASTM D 422	
	Liquid limit of Soils	ASTM D 4318	
	Plastic limit and plasticity index of soils	ASTM D 4318	
	Moisture-density relations of soil	AASHTO T 180, Method B or D	

3. Quality Control Testing During Construction: Soil Test on materials shall be performed during construction as follows:

MATERIAL	REQUIREMENT	TEST METHOD	MATERIAL TESTED AND NUMBER OF TESTS
Soil material-in-place after compaction	Density of soil-in-place	ASTM D 1556 Sand Cone Method or ASTM D 2922 Nuclear Method	At least three daily for each subgrade soil material, and for each layer of soil material; additional tests whenever there is any change in moisture

4. Field Testing Facilities at Subbase Mixing Plant: Field-testing facilities for the purpose of testing subbase course material at the mixing plant shall be provided by the Contractor's soil-testing service.
5. Reports: No soil material shall be used until soil test reports have been reviewed and approved.
6. Evaluation of Test Results
   a. Soil materials of any classification shall not have a moisture content at the time of compaction that would be classified as unsatisfactory soil materials in the paragraph entitled, "Definitions."
   b. Results of density of soil-in-place tests shall be considered satisfactory if the average of any group of four consecutive density tests which may be selected is in each instance equal to or greater than the specified density, and if no density test has a value more than 2 percentage points below the specified density.

E. Use Of Explosives:
1. Explosives shall not be used or brought to the project site without prior written approval. Such approval shall not be construed as relieving the Contractor of responsibility for injury to persons or for damage to property due to blasting operations. Blasting shall be performed by skilled personnel in accordance with governing authorities and as approved. Minimum safety requirements for blasting shall be in accordance with OSHA Regulations 29 CFR 1926, Subpart U.
   OR
   The use of explosives will not be permitted.

F. Protection Of Persons And Property
1. Excavations shall be barricaded and posted with warning signs for the safety of persons. Warning lights shall be provided during hours of darkness.
2. Structures, utilities, sidewalks, pavements, and other facilities immediately adjacent to excavations shall be protected against damage including settlement, lateral movement, undermining, and washout.
3. Topsoil removal operations shall be conducted to ensure safety of persons and to prevent damage to existing structures and utilities, construction in progress, trees and vegetation to remain standing, and other property.

G. Construction Equipment List: Construction Equipment List for all major equipment to be used in this section shall be submitted to the Owner prior to start of work.

H. Existing Conditions
1. Records of Existing Conditions shall be submitted by the Contractor prior to the start of work. The Contractor shall verify the existing conditions are correct as shown on the plans and described in the specifications. the Owner shall be notified immediately if any discrepancies are found.

2. Records of underground utilities, Location of Utilities, Location of Inspection, Location of Tests, and Location of Approved Utilities shall be submitted to the Owner prior to start of work.

1.2 PRODUCTS

A. Materials
1. Satisfactory Materials shall mean AASHTO M 145 (ASTM D 3282), Soil Classification Groups A-1, A-2-4, A-2-5, and A-3.
2. Unsatisfactory Materials shall mean AASHTO M 145, Soil Classification Groups A-2-6, A-2-7, A-4, A-5, A-6, and A-7, peat and other highly organic soils, and soil materials of any classification that have a moisture content, at the time of compaction, beyond the range of 1 percentage point below and 3 percentage points above the optimum moisture content of the soil material as determined by moisture-density relations test.
3. Topsoil shall be any soil removed from the project site which consists of clay or sandy loam. The topsoil shall be reasonably free from subsoil, clay lumps, brush, objectionable weeds, and other litter, and shall be free from stones, stumps, roots, and other objectionable material larger than 2 in. (50 mm) in any dimension.
4. Compost shall be yard trimmings or yard waste compost processed and graded according to state and local regulations.
5. Topsoil Blend: Where insufficient topsoil is removed from the project site for later reuse, the topsoil removed shall be stockpiled and blended with compost at the site to achieve the required volume.

1.3 EXECUTION

A. Blasting:
1. Where explosives are used in rock excavation, the charges shall be so proportioned and placed that they will not loosen the rock outside the excavation lines indicated, or as specified. Contractor shall remove, at no additional cost, any material outside the authorized cross section that may be shattered or loosened by blasting.
OR
Blasting is not required or permitted.

B. Conservation Of Topsoil: Topsoil shall be stripped to a depth of not less than 4 in. (100 mm); when stored it shall be kept separate from other excavated materials, free of roots, stones, and other undesirable materials. Where indicated, topsoil shall be removed without contamination with subsoil and spread on areas already graded and prepared for topsoil, or when so specified, topsoil shall be transported and deposited in stockpiles convenient to areas that are to receive application of the topsoil later or at locations indicated or specified by the Owner. Topsoil blend shall be used on all embankments when there is not enough topsoil available.

C. Excavation
1. Excavations specified shall be done on either a classified or unclassified basis as directed by the Owner.
2. Contractor shall perform excavation of every type of material encountered by cutting accurately to the cross sections to the lines, grades, and elevations indicated. Grading shall be in conformity with the typical sections indicated and the tolerances specified in paragraph entitled, "Finishing."
3. Satisfactory excavated materials shall be transported to and placed in fill or embankment areas within the limits of the work. Unsatisfactory materials encountered within the limits of the work shall be excavated below grade and replaced with satisfactory materials as directed. Surplus satisfactory excavated material not required for fill or embankment shall be disposed in areas approved for surplus materials storage or designated waste areas. Unsatisfactory excavated material shall be disposed in designated waste or spoil areas. During construction, excavation

and filling shall be performed in a manner and sequence that will provide proper drainage at all times. Material required for fill or embankment in excess of that produced by excavation within the grading limits shall be excavated from the borrow areas indicated or from other approved areas selected by the Owner.

4. Excavation of Ditches, Gutters, and Channels: Care shall be taken not to excavate ditches and gutters below grades shown. Excessive open-ditch or gutter excavation shall be backfilled with suitable materials to grades indicated at no additional cost. Materials excavated shall be disposed as indicated, except that in no case shall material be deposited less than 3 ft. (1 m) from the edge of a ditch. Contractor shall maintain excavations free from debris until final acceptance of the work.
5. Excavation for Drainage Structures
   a. Dimensions and elevations of footings and foundation excavations indicated are only approximate and may be changed if necessary to ensure adequate foundation support. Trenches and foundation pits shall be of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations. Rock or other hard foundation material shall be cleaned of loose debris and cut to a firm surface, either level, stepped, or serrated. Loose disintegrated rock and thin strata shall be removed. When concrete or masonry is to be placed in an excavated area, special care shall be taken not to disturb the bottom of the excavation. Excavation to the final grade level shall not be made until just before concrete or masonry is to be placed.
   b. Where pile foundations are to be used, the excavation of each pit shall be stopped at an elevation 1 ft. (300 mm) above the base of the footing, as specified, before piles are driven. After pile driving has been completed, loose and displaced material shall be removed and excavation completed, leaving a smooth, solid, undisturbed surface to receive concrete or masonry.
6. Protection or Removal of Utility Lines: Existing Utilities that are indicated to be retained, or the locations of which have been ascertained from the Owner utility drawings, as well as utility lines encountered during excavation, shall be protected from damage during excavation and backfilling. However, reliance on the information obtained from the Owner drawings does not absolve the Contractor of responsibility for damages, so careful hand methods shall be used to verify the location of underground utilities. Damage shall be reported immediately and satisfactorily repaired by the Contractor at no additional cost. The Contractor shall provide sketches of existing conditions if there are variances, as well as any modifications, on "as-built" drawings. When utility lines that are to be removed are encountered within the area of operations, the Contractor shall give notice in ample time for the necessary measures to be taken to prevent interruption of service.

D. Classification Of Excavation: Excavations specified shall be done on either a classified or unclassified basis as provided for under the item designations of the Contract.

E. Utilization Of Excavation Materials: Unsatisfactory materials removed from excavations shall be disposed in designated areas. Satisfactory material removed from excavations shall be used, insofar as practicable, in the construction of fills, embankments, subgrades, shoulders, bedding; as backfill; and for similar purposes. No satisfactory excavated material shall be wasted without specific written authorization. Satisfactory material authorized to be wasted shall be disposed in designated areas approved for surplus material storage or designated waste areas as directed. Coarse rock from excavations shall be stockpiled and used for constructing slopes of embankments adjacent to streams, for constructing slopes or sides and bottoms of channels, and for protecting against erosion. Hand placing of coarse rock from excavations will not be required. Excavated material shall not be disposed in a manner as to obstruct the flow of any stream, endanger a partly finished structure, impair the efficiency or appearance of any structure, or be detrimental to the completed work in any way.

F. Selection Of Borrow Material: Borrow material shall be selected to meet the requirements and conditions of the particular fill or embankment for which it is to be used. Borrow material shall be obtained from the borrow areas indicated on the plans or from other approved sources, either private or within the limits of the project site, selected by the Contractor. Unless otherwise provided in the

contract, the Contractor shall obtain from the Owner the right to procure material, pay all royalties and other charges involved, and bear all expense of developing the sources, including rights-of-way for hauling. Borrow material from approved sources on the Owner-controlled land may be obtained without payment of royalties. Unless specifically provided, no borrow shall be obtained within the limits of the project site without prior written approval. Necessary clearing, grubbing, and satisfactory drainage of borrow pits and the disposal of debris shall be considered related operations to the borrow excavation and shall be performed by the Contractor at no additional cost to the Owner.

G. Opening And Drainage Of Excavation And Borrow Pits: The Contractor shall give notice sufficiently in advance of the opening of any excavation or borrow pit to permit elevations and measurements of the undisturbed ground surface to be taken. Unless otherwise permitted, borrow pits and other excavation areas shall be excavated in such manner as will afford adequate drainage. Overburden and other spoil material shall be transported to designated spoil areas or otherwise disposed as directed. Borrow pits shall be neatly trimmed and left in such shape as will facilitate accurate measurements after the excavation is completed.

H. Grading Areas: When so provided and indicated, work under contract will be divided into grading areas, within which satisfactory excavated material shall be placed in embankments, fills, and required backfills. Contractor shall not haul satisfactory material excavated in one grading area to another grading area, except when so directed in writing.

I. Preparation Of Ground Surface For Embankments
   1. Ground surface on which fill is to be placed shall be stripped of live, dead, or decayed vegetation, rubbish, debris, and other unsatisfactory material; shall be plowed, disked, or otherwise broken up; pulverized; moistened or aerated as necessary; mixed; and compacted to at least 90 percent maximum density for cohesive materials or 100 percent maximum density for cohesionless materials.
   2. Compaction shall be accomplished by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment. The prepared ground surface shall be scarified and moistened or aerated just prior to placement of embankment materials to ensure adequate bond between embankment material and the prepared ground surface.

J. Embankments
   1. Earth Embankments
      a. Earth embankments shall be constructed from satisfactory materials free of organic or frozen material and rocks with maximum dimensions not greater than 3 in. (75 mm). The material shall be placed in successive horizontal layers of loose material not more than 6 in. (150 mm) in depth. Each layer shall be spread uniformly on a prepared surface, i.e., a soil surface that has been moistened or aerated and scarified plowed, disked, or otherwise broken up in such a manner that the fill will bond with the surface on which it is placed, mixed, and compacted to at least 90 percent maximum density for borrow materials or 100 percent maximum density for excavated materials. Compaction requirements for the upper portion of earth embankments forming subgrade for pavements shall be identical to those requirements specified in paragraph entitled, "Subgrade Preparation."
      b. Compaction shall be accomplished by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment.
   2. Rock Embankments
      a. Rock embankments shall be constructed from material essentially classified as rock excavation, placed in successive horizontal layers of loose material not more than 8 to 10 in. (200 to 250 mm) in depth. Pieces of rock larger than 8 to 10 in. (200 to 250 mm) in greatest dimension shall not be used.
      b. Each layer of material shall be spread uniformly and shall be completely saturated and compacted to density as directed by the Owner.

c. Each layer of material shall be spread uniformly and shall be completely saturated and compacted until the interstices are filled with well-compacted materials and the entire layer is a dense, compacted mass.
d. Each successive layer of material shall adequately bond to the material on which it is placed.
e. Compaction shall be accomplished with vibratory compactors with a minimum static weight of 20,000 lbs. (90 kN), heavy rubber-tired rollers weighing not less than 25,000 lbs. (110 kN) or steel-wheeled rollers with a loaded weight of not less than 4,000 lb/ft (58,400 N/m) of drum length.
f. Rock shall not be used above a point 6 in. (150 mm) below the surface of an embankment that is to be paved.

K. Subgrade Preparation
1. Construction
a. Subgrade shall be shaped to line, grade, and cross section and compacted as specified. This operation shall include plowing, disking, and any moistening or aerating required to obtain proper compaction. Soft or otherwise unsatisfactory material shall be removed and replaced with satisfactory excavated material or other approved material as directed. Rock encountered in the cut sections shall be excavated to a depth of 6 in. (150 mm) below finished grade for the subgrade. Low areas resulting from removal of unsatisfactory material or excavation of rock shall be brought up to required grade with satisfactory materials, and the entire subgrade shall be shaped to line, grade, and cross section and compacted as specified.
b. After rolling, the surface of the subgrade for roadways and/or airfields shall indicate a deviation not greater than 3/8 in. (10 mm) when tested with a 10-ft (3.0 m) straightedge applied both parallel with, and at right angles to, the centerline of the area.
c. Elevation of the finished subgrade shall vary not more than 1/4-in. (6 mm) from the established grade and approved cross section.
2. Compaction: Compaction for pavements and shoulders shall be accomplished with approved equipment until the layer is compacted to the full depth to at least 95 percent maximum density.

L. Shoulder Construction: Shoulders shall be constructed of satisfactory excavated or borrow materials or as otherwise indicated on the plans. Shoulders shall be constructed as soon as possible after adjacent paving is complete, but in the case of rigid pavements, shoulders shall not be constructed until permission has been obtained. The entire shoulder area shall be compacted to at least the percentage of maximum density as specified for specific ranges of depth below the surface of the shoulder. Compaction shall be accomplished with approved equipment. Shoulder construction shall be done in proper sequence in such a manner that adjacent ditches will be drained effectively and no damage of any kind is done to the adjacent, completed pavement. The completed shoulders shall be true to alignment and grade and shaped to drain in conformity with the cross section indicated.

M. Finishing: Surface of excavations, embankments, and subgrades shall be finished to a reasonably smooth and compact surface substantially in accordance with the lines, grades, and cross sections or elevations indicated. Degree of finish for graded areas shall be within 1/10 ft (30 mm) of the grades and elevations indicated, except that the degree of finish for subgrades shall be as specified. Gutters and ditches shall be finished as indicated. Surface of areas to be turfed shall be finished to a smoothness suitable for the application of turfing materials.

N. Subgrade And Embankment Protection: During construction, embankments and excavations shall be kept shaped and drained. Ditches and drains along subgrade shall be maintained in such a manner as to drain effectively at all times. Finished subgrade shall not be disturbed by traffic or other operations and shall be protected and maintained by the Contractor in a satisfactory condition until ballast, subbase, base, or pavement is placed. Storage or stockpiling materials on finished subgrade will not be permitted. Subbase, base course, ballast, or pavement shall not be laid until the subgrade has been checked and approved, and in no case shall subbase, base, surfacing, pavement, or ballast be placed on a muddy, spongy, or frozen subgrade.

END OF SECTION 31 23 16 26

Task	Specification	Specification Description
31 23 16 26	31 01 20 00	Earthwork
31 23 16 33	31 01 20 00	Earthwork
31 23 16 36	31 23 16 13	Excavation Support And Protection
31 23 16 36	31 01 20 00	Earthwork

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SECTION 31 23 19 00 - DEWATERING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for dewatering. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Performance Requirements
1. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.
a. Delegated Design: Design dewatering system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
b. Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, that excavation does not flood, and that damage to subgrades and permanent structures is prevented.
c. Prevent surface water from entering excavations by grading, dikes, or other means.
d. Accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.
e. Remove dewatering system when no longer required for construction.

C. Submittals
1. Shop Drawings: For dewatering system. Show arrangement, locations, and details of wells and well points; locations of risers, headers, filters, pumps, power units, and discharge lines; and means of discharge, control of sediment, and disposal of water.
a. Include layouts of piezometers and flow-measuring devices for monitoring performance of dewatering system.
b. Include a written plan for dewatering operations including control procedures to be adopted if dewatering problems arise.
2. Delegated-Design Submittal: For dewatering system indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

D. Quality Assurance
1. Regulatory Requirements: Comply with governing EPA notification regulations before beginning dewatering. Comply with hauling and disposal regulations of authorities having jurisdiction.
2. Preinstallation Conference: Conduct conference at Project site.

E. Project Conditions
1. Interruption of Existing Utilities: Do not interrupt any utility serving facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
a. Notify the Owner no fewer than two days in advance of proposed interruption of utility.
b. Do not proceed with interruption of utility without the Owner's written permission.
2. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements, establishing exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.
a. During dewatering, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations for comparison with original elevations. Promptly notify the Owner if

changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.

1.2 PRODUCTS (Not Used)

1.3 EXECUTION

A. Preparation
1. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.
   a. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site and surrounding area.
   b. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.
2. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
   a. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
3. Provide temporary grading to facilitate dewatering and control of surface water.
4. Monitor dewatering systems continuously.
5. Promptly repair damages to adjacent facilities caused by dewatering.
6. Protect and maintain temporary erosion and sedimentation controls, which are specified in Division 31 Section "Site Clearing" during dewatering operations.

B. Installation
1. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.
   a. Space well points or wells at intervals required to provide sufficient dewatering.
   b. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.
2. Before excavating below ground-water level, place system into operation to lower water to specified levels. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed or until dewatering is no longer required.
3. Provide an adequate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Install sufficient dewatering equipment to drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.
   a. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.
4. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.
   a. Maintain piezometric water level a minimum of 24 inches (600 mm) **OR** 60 inches (1500 mm), **as directed**, below surface of excavation.
5. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.
6. Provide standby equipment on site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, restore damaged structures and foundation soils at no additional expense to the Owner.

a. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches (900 mm) below overlying construction.

7. Damages: Promptly repair damages to adjacent facilities caused by dewatering operations.

END OF SECTION 31 23 19 00

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Task	Specification	Specification Description
31 23 19 00	21 05 23 00	Piped Utilities Basic Materials And Methods
31 23 23 23	31 01 20 00	Earthwork

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SECTION 31 24 13 00 - LEVEE CLOSURE

1.1 GENERAL

A. Description Of Work
   1. This specification covers the furnishing of labor and materials for providing levee closures.

1.2 PRODUCTS - (Not Used)

1.3 EXECUTION

A. If there is deemed, by the Owner, to be considerable risk of flooding involved with removing drainage structures and gates in the existing Levee System, the Contractor shall perform the work of this contract as follows:
   1. Only one drainage structure/flap gate will be allowed to be disrupted at one time. All proposed work at each drainage structure shall be completed before proceeding to the next structure.
   2. The Contractor shall have all materials required for each structure installation secured on site, before beginning construction on that structure.
   3. The Contractor shall have all necessary materials on site to temporarily plug existing and/or proposed piping through the levee.
   4. Weather and river flow conditions shall be monitored at all times by the Contractor while each drainage structure is open to flow. The Contractor shall construct an adequate closure in a timely fashion to plug the drainage structure preventing flow through the levee.

END OF SECTION 31 24 13 00

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Task	Specification	Specification Description
31 24 13 00	31 01 20 00	Earthwork
31 24 13 00	31 23 16 26	Embankment

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SECTION 31 25 14 13 - GEOSYNTHETIC FABRIC

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing of labor, material and equipment for the installation of geosynthetic fabric.

1.2 PRODUCTS

A. Materials
1. Erosion Control Fabric - Photo and biodegradable plastic Curlex Blanket as manufactured by American Excelsior Co. or approved equal.
2. Drainage/Leach Bed - Non-woven polypropylene/polyethylene fabric, Mirafi 140N or approved equal.
3. Road Base and Structure Reinforcement - Woven polypropylene fabric, Mirafi 600X or approved equal.
4. Sediment and Job Site erosion control - woven polypropylene fabric - Envirofence by Mirafi or approved equal.

1.3 EXECUTION

A. For sediment and job site erosion control fabric, the Contractor shall provide and install silt fence as detailed on the Storm Water Management and Erosion Control Plan. It shall be the Contractor's option to provide fabricated reinforced silt fence or prefabricated units, unless otherwise noted. In all installations, the bottom flap of filter cloth shall be firmly embedded into undisturbed or stabilized grade. Embedment shall resist pullout and prevent flow under the installation.

END OF SECTION 31 25 14 13

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Task	Specification	Specification Description
31 25 14 13	01 56 26 00	Sediment Removal
31 25 14 13	01 56 26 00a	Erosion Control
31 25 14 16	01 56 26 00	Sediment Removal
31 25 14 16	31 25 14 13	Geosynthetic Fabric
31 25 14 16	01 56 26 00a	Erosion Control

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SECTION 31 25 14 23 - UNIT PAVERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for unit pavers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Brick pavers set in aggregate, bituminous or mortar setting beds.
b. Concrete pavers set in aggregate, bituminous or mortar setting beds.
c. Asphalt-block pavers set in bituminous setting beds.
d. Stone pavers set in aggregate or mortar setting beds.
e. Plastic or Steel or Aluminum edge restraints.
f. Cast-in-place concrete edge restraints.
g. Precast concrete curbs.
h. Stone curbs.

C. Preconstruction Testing
1. Preconstruction Adhesion and Compatibility Testing: Submit to latex-additive manufacturer, for testing as indicated below, samples of paving materials that will contact or affect mortar and grout that contain latex additives.
a. Use manufacturer's standard test methods to determine whether mortar and grout materials will obtain optimum adhesion with, and will be nonstaining to, installed pavers and other materials constituting paver installation.

D. Action Submittals
1. Product Data: For materials other than water and aggregates.
2. Product Data: For the following:
a. Pavers.
b. Bituminous setting materials.
c. Mortar and grout materials.
d. Edge restraints.
e. Precast concrete curbs.
f. Stone curbs.
3. LEED Submittals:
a. Product Certificates for Credit MR 5: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.
4. Adhesion and Compatibility Test Reports: From latex-additive manufacturer for mortar and grout containing latex additives.
5. Sieve Analyses: For aggregate setting-bed materials, according to ASTM C 136.
6. Samples for Initial Selection: For the following:
a. Each type of unit paver indicated.
b. Joint materials involving color selection.
c. Exposed edge restraints involving color selection.
d. Precast concrete curbs.
e. Granite for stone curbs.
7. Samples for Verification:

a. Full-size units of each type of unit paver indicated. Assemble no fewer than five Samples of each type of unit on suitable backing and grout joints.]
b. Joint materials.
c. Exposed edge restraints.
d. Precast concrete curbs.
e. Stone curbs.

E. Quality Assurance
1. Source Limitations: Obtain each type of unit paver, joint material, and setting material from single source with resources to provide materials and products of consistent quality in appearance and physical properties.
2. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
a. Approved mockups may become part of the completed Work if undisturbed at time of Final Completion.
3. Preinstallation Conference: Conduct conference at Project site.

F. Delivery, Storage, And Handling
1. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.
2. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.
3. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.
4. Store liquids in tightly closed containers protected from freezing.
5. Store asphalt cement and other bituminous materials in tightly closed containers.

G. Project Conditions
1. Cold-Weather Protection: Do not use frozen materials or build on frozen subgrade or setting beds.
2. Weather Limitations for Bituminous Setting Bed:
a. Install bituminous setting bed only when ambient temperature is above 40 deg F (4 deg C) and when base is dry.
b. Apply asphalt adhesive only when ambient temperature is above 50 deg F (10 deg C) and when temperature has not been below 35 deg F (2 deg C) for 12 hours immediately before application. Do not apply when setting bed is wet or contains excess moisture.
3. Weather Limitations for Mortar and rout:
a. Cold-Weather Requirements: Comply with cold-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602.
b. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602. Provide artificial shade and windbreaks and use cooled materials as required. Do not apply mortar to substrates with temperatures of 100 deg F (38 deg C) and higher.
1) When ambient temperature exceeds 100 deg F (38 deg C), or when wind velocity exceeds 8 mph (13 km/h) and ambient temperature exceeds 90 deg F (32 deg C), set pavers within 1 minute of spreading setting-bed mortar.

1.2 PRODUCTS

A. Brick Pavers
1. Regional Materials: Provide brick pavers that have been manufactured within 500 miles (800 km) of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles (800 km) of Project site.

2. Brick Pavers: Light-traffic paving brick; ASTM C 902; Class SX for exposure to freezing weather **OR** Class MX for exterior uses that do not expose brick to freezing, **as directed**, Type I for locations exposed to extensive abrasion, such as sidewalks and driveways in public spaces **OR** Type II for locations exposed to intermediate abrasion, such as heavily traveled residential walkways and driveways **OR** Type III for locations exposed to low abrasion, such as floors and patios exposed in single-family homes, **as directed**. Application PS normal tolerance for installation with grouted joints **OR** Application PX close tolerance for ungrouted joints **OR** Application PA non-uniform sized for decorative effect, **as directed**. Provide brick without frogs or cores in surfaces exposed to view in the completed Work.
   a. Thickness: 1-1/4 inches (32 mm) **OR** 1-1/2 inches (38 mm) **OR** 1-5/8 inches (41 mm) **OR** 2-1/4 inches (57 mm) **OR** 2-5/8 inches (67 mm), **as directed**.
   b. Face Size: 3-3/4 by 7-1/2 inches (95 by 190 mm) **OR** 3-5/8 by 7-5/8 inches (92 by 194 mm) **OR** 3-5/8 by 11-5/8 inches (92 by 295 mm) **OR** 7-5/8 by 7-5/8 inches (194 by 194 mm) **OR** 4 by 8 inches (102 by 203 mm) **OR** 4 by 12 inches (102 by 305 mm) **OR** 8 by 8 inches (203 by 203 mm), **as directed**.
   c. Color: As selected from manufacturer's full range.
3. Brick Pavers: Heavy vehicular paving brick; ASTM C 1272, Type F, Application PX **OR** Type R, Application PS **OR** Type R, Application PX **OR** Type R, Application PA, **as directed**. Provide brick without frogs or cores in surfaces exposed to view in the completed Work.
   a. Type R is for units set in a mortar setting bed or a bituminous setting bed supported by an adequate base. Type F is for units set in a sand setting bed with sand between the pavers. Application PS is for general use; Application PX is for pavers with close dimensional tolerances. Application PX must be selected if specifying Type F
   b. Thickness: 2-1/4 inches (57 mm) **OR** 2-5/8 inches (67 mm), **as directed**.
   c. Face Size: 3-3/4 by 7-1/2 inches (95 by 190 mm) **OR** 3-5/8 by 7-5/8 inches (92 by 194 mm) **OR** 3-5/8 by 11-5/8 inches (92 by 295 mm) **OR** 7-5/8 by 7-5/8 inches (194 by 194 mm) **OR** 4 by 8 inches (102 by 203 mm) **OR** 4 by 12 inches (102 by 305 mm) **OR** 8 by 8 inches (203 by 203 mm), **as directed**.
   d. Color: As selected from manufacturer's full range.
4. Efflorescence: Brick shall be rated "not effloresced" when tested according to ASTM C 67.
5. Temporary Protective Coating: Precoat exposed surfaces of brick pavers with a continuous film of a temporary protective coating that is compatible with brick, mortar, and grout products and can be removed without damaging grout or brick. Do not coat unexposed brick surfaces; handle brick to prevent coated surfaces from contacting backs or edges of other units. If, despite these precautions, coating does contact bonding surfaces of brick, remove coating from bonding surfaces before setting brick.

B. Concrete Pavers
1. Concrete Pavers: Solid interlocking paving units complying with ASTM C 936 and resistant to freezing and thawing when tested according to ASTM C 67, made from normal-weight aggregates.
   a. Thickness: 2-3/8 inches (60 mm) **OR** 3-1/8 inches (80 mm), **as directed**.
   b. Face Size and Shape: 3-7/8 inches (98 mm) square **OR** 4-7/16 inches (113 mm) **OR** 8-7/8 inches (225 mm) **OR** 9 inches (229 mm)square, **as directed**.
   c. Face Size and Shape: 3-7/8-by-7-7/8 inch (98-by-200 mm) **OR 4-by-8-inch (102-by-203-mm) OR** 4-7/16-by-8-7/8 inch (113-by 225-mm), **as directed,** rectangle.
   d. Face Size and Shape: 5-1/2-inch (140-mm) octagon with attached 3-1/2-inch (89-mm) square **OR** 4-1/2-by-9 inch (114-by-229 mm) rectangle with saw-tooth edges **OR** 4-3/4-inch (121-mm) rectangular and trapezoidal units arranged in semicircular courses to produce fan-shaped pattern, **as directed**.
   e. Color: As selected from manufacturer's full range.
2. Concrete Pavers: Solid paving units, made from normal-weight concrete with a compressive strength not less than 5000 psi (34 MPa) **OR** 6000 psi (41 MPa), **as directed**, water absorption not more than 5 percent according to ASTM C 140, and no breakage and not more than 1 percent mass loss when tested for freeze-thaw resistance according to ASTM C 67.

a. Thickness: 1-5/8 inches (41 mm) **OR** 1-3/4 inches (45 mm) **OR** 2 inches (51 mm) **OR** 2-3/8 inches (60 mm), **as directed**.
b. Face Size and Shape: 8-7/8 inches (225 mm) square **OR** 9 inches (229 mm) square **OR** 12 inches (305 mm) square **OR** 18 inches (457 mm) square **OR** 24 inches (610 mm) square, **as directed**.
c. Face Size and Shape: 9-by-18 inch (229-by-457 mm) **OR** 12-by-24 inch (305-by-610 mm), **as directed,** rectangle.
d. Face Size and Shape: As indicated.
e. Color: As selected from manufacturer's full range.

3. Concrete Pavers: Solid paving units complying with ASTM C 1491, made from lightweight concrete.
a. Thickness: 1-5/8 inches (41 mm) **OR** 1-3/4 inches (45 mm) **OR** 2 inches (51 mm), **as directed**.
b. Face Size and Shape: 9 inches (229 mm) square **OR** 12 inches (305 mm) square **OR** 18 inches (457 mm) square, **as directed.**
c. Color: As selected from manufacturer's full range.

C. Asphalt-Block Pavers
1. Asphalt-Block Pavers: Solid units made from asphalt cement complying with ASTM D 312, Type III; inorganic stone dust or cement filler; and coarse aggregate, consisting of clean, hard, unweathered stone crushed into angular particles varying in size up to 3/8 inch (9.5 mm).
a. Thickness: 1-1/4 inches (32 mm) **OR** 2 inches (51 mm) **OR** 3 inches (76 mm), **as directed**.
b. Face Size: 4 by 6 inches (102 by 152 mm) **OR** 6 by 6 inches (152 by 152 mm) **OR** 8 by 8 inches (203 by 203 mm) **OR** 5 by 12 inches (127 by 305 mm) **OR** 6 by 12 inches (152 by 305 mm) **OR** 8-inch- (203-mm-) wide hexagon, **as directed**.
c. Finish: Natural, smooth **OR** Ground **OR** Ground and sandblasted, **as directed**.
d. Color: As selected from manufacturer's full range.

D. Stone Pavers
1. Granite Pavers: Rectangular paving slabs made from granite complying with ASTM C 615
a. Color and Grain: Light gray **OR** Dark gray **OR** Buff **OR** White **OR** Black **OR** Pink, **as directed,** with medium **OR** fine, **as directed,** grain.
b. Finish: Honed **OR** Thermal, **as directed.**
c. Match Architect's samples for color, finish, and other stone characteristics relating to aesthetic effects.
d. Thickness: Not less than 3/4 inch (20 mm) **OR** 30 mm **OR** 1-1/4 inches (32 mm) **OR** 1-5/8 inches (40 mm), **as directed**, unless otherwise indicated.
e. Face Size: 9 inches (229 mm) square **OR** 12 inches (305 mm) square **OR** 18 inches (457 mm) square **OR** 9 by 18 inches (229 by 457 mm)**, as directed.**

2. Limestone Pavers: Rectangular paving slabs made from limestone complying with ASTM C 568.
a. Classification: II Medium-Density **OR** III High-Density**, as directed**.
b. Stone Abrasion Resistance: Minimum value of 10, based on testing according to ASTM C 241 or ASTM C 1353.
c. Finish: Smooth **OR** Chat sawed **OR** Shot sawed**, as directed.**
d. Match Architect's samples for color, finish, and other stone characteristics relating to aesthetic effects.
e. Thickness: Not less than 1 inch (25 mm) **OR** 1-1/4 inches (32 mm) **OR** 1-5/8 inches (40 mm) **OR** 2 inches (50 mm)**, as directed,** unless otherwise indicated.
f. Face Size: 9 inches (229 mm) square **OR** 12 inches (305 mm) square **OR** 18 inches (457 mm) square **OR** 9 by 18 inches (229 by 457 mm), **as directed.**

3. Marble Pavers: Rectangular paving slabs made from marble complying with ASTM C 503.
a. Stone Abrasion Resistance: Minimum value of 10, based on testing according to ASTM C 241 or ASTM C 1353.
b. Description: Uniform, fine- to medium-grained, white stone with only slight veining.

c. Finish: Honed **OR as directed.**
d. Match samples for color, finish, and other stone characteristics relating to aesthetic effects.
e. Thickness: Not less than 3/4 inch (20 mm) **OR** 30 mm **OR** 1-1/4 inches (32 mm), **as directed**.
f. Face Size: 9 inches (229 mm) square**OR**12 inches (305 mm) square **OR** 18 inches (457 mm) square **OR** 9 by 18 inches (229 by 457 mm) **as directed**.

4. Quartz-Based Stone Pavers: Rectangular paving slabs **OR** Random polygonal flagstones made from quartz-based stone complying with ASTM C 616, Classification I Sandstone **OR** II Quartzitic Sandstone **OR** III Quartzite, **as directed**.
a. Stone Abrasion Resistance: Minimum value of 10, based on testing according to ASTM C 241 or ASTM C 1353.
b. Finish: Sand rubbed **OR** Natural cleft **OR** Thermal, **as directed**.
c. Match samples for color, finish, and other stone characteristics relating to aesthetic effects.
d. Thickness: Not less than 1 inch (25 mm) **OR** 1-1/4 inches (32 mm) **OR** 1-1/2 inches (38 mm) **OR** 1-5/8 inches (40 mm) **OR** 2 inches (50 mm), **as directed**.
e. Face Size: 9 inches (229 mm) square **OR** 12 inches (305 mm) square **OR** 18 inches (457 mm) square **OR** 9 by 18 inches (229 by 457 mm), **as directed**.

5. Slate Pavers: Rectangular paving slabs **OR** Random polygonal flagstones made from slate complying with ASTM C 629, Classification I Exterior, with a fine, even grain and unfading color, from clear, sound stock.
a. Color: Black **OR** Blue-black **OR** Gray **OR** Blue-gray **OR** Green **OR** Purple **OR** Mottled purple and green **OR** Red, **as directed**.
b. Stone Abrasion Resistance: Minimum value of 8, based on testing according to ASTM C 241 or ASTM C 1353.
c. Finish: Honed **OR** Sand rubbed **OR** Natural cleft, **as directed**.
d. Match samples for color, finish, and other stone characteristics relating to aesthetic effects.
e. Thickness: Not less than 1/2 inch (13 mm) **OR** 3/4 inch (20 mm) **OR** 1 inch (25 mm), **as directed**.
f. Face Size: 9 inches (229 mm) square **OR** 12 inches (305 mm) square **OR** 18 inches (457 mm) square **OR** 9 by 18 inches (229 by 457 mm), **as directed**.

6. Travertine Pavers: Rectangular paving slabs made from travertine complying with ASTM C 1527, Classification I Exterior.
a. Stone Abrasion Resistance: Minimum value of 10, based on testing according to ASTM C 241 or ASTM C 1353.
b. Cut: Vein cut.
c. Filling: Fill pores on faces of stone with cementitious filler of color as selected by the Owner.
d. Finish: Honed **OR as directed**.
e. Match samples for color, finish, and other stone characteristics relating to aesthetic effects.
f. Thickness: Not less than 3/4 inch (20 mm) **OR** 30 mm **OR** 1-1/4 inches (32 mm), **as directed**.
g. Face Size: 9 inches (229 mm) square **OR** 12 inches (305 mm) square **OR** 18 inches (457 mm) square **OR** 9 by 18 inches (229 by 457 mm), **as directed.**

7. Rough-Stone Pavers: Rectangular tumbled paving stones, with split or thermal-finished faces and edges, made from granite complying with ASTM C 615.
a. Granite Color and Grain: Light gray **OR** Dark gray **OR** Buff **OR** White **OR** Black **OR** Pink, **as directed,** with medium **OR** fine, **as directed,** grain.
b. Thickness: 1-1/4 inches (32 mm) **OR** 2 inches (51 mm) **OR** 3 inches (76 mm) **OR** 4 inches (102 mm) **OR** 4 inches (102 mm), plus or minus 1/2 inch (13 mm), **as directed**.
c. Face Size: 4 by 4 inches (100 by 100 mm), plus or minus 1/2 inch (13 mm) **OR** 3 to 5 inches (75 to 125 mm) by 8 to 12 inches (200 to 300 mm), **as directed**.

E. Curbs And Edge Restraints
1. Plastic Edge Restraints: Manufacturer's standard triangular PVC extrusions 1-3/4 inches (45 mm) high by 3-1/2 inches (89 mm) wide **OR** 3-1/8 inches (79 mm) high by 9-1/2 inches (241 mm) wide, **as directed,** designed to serve as edge restraints for unit pavers; rigid type for straight

edges and flexible type for curved edges, with pipe connectors and 3/8-inch (9.5-mm) diameter by 12-inch- (300-mm-) long steel spikes.

2. Steel Edge Restraints: Manufacturer's standard painted steel edging 3/16 inch (4.8 mm) thick by 4 inches (100 mm) high **OR** 1/4 inch (6.4 mm) thick by 5 inches (125 mm) high, **as directed** with loops pressed from or welded to face to receive stakes at 36 inches (900 mm) o.c., and steel stakes 15 inches (380 mm) long for each loop.
   a. Color: As selected from manufacturer's full range.
3. Aluminum Edge Restraints: Manufacturer's standard straight, 1/8-inch- (3.2-mm-) thick by 4-inch- (100-mm-) high **OR** straight, 3/16-inch- (4.8-mm-) thick by 4-inch- (100-mm-) high **OR** L-shaped, 1/8-inch- (3.2-mm-) thick by 1-3/8-inch- (35-mm-) high **OR** L-shaped, 3/16-inch- (4.8-mm-) thick by 2-1/4-inch- (57-mm-) high, **as directed** extruded-aluminum edging with loops pressed from face to receive stakes at 12 inches (300 mm) o.c., and aluminum stakes 12 inches (300 mm) long for each loop.
4. Job-Built Concrete Edge Restraints: Comply with requirements in Division 3 Section "Cast-in-Place Concrete" for normal-weight, air-entrained, ready-mixed concrete with minimum 28-day compressive strength of 3000 psi (20 MPa).
5. Precast Concrete Curbs: Made from normal-weight concrete with a compressive strength not less than 5000 psi (34 MPa) **OR** 6000 psi (41 MPa), **as directed** and water absorption not more than 5 percent, in shapes and sizes indicated.
6. Stone Curbs: Granite curbing, with face battered 1 inch per foot (1:12), produced in random lengths not less than 36 inches (900 mm) from granite complying with ASTM C 615.
   a. Granite Color and Grain: Light gray **OR** Dark gray **OR** Buff **OR** White **OR** Black **OR** Pink, **as directed** with fine **OR** medium **OR** coarse grain, **as directed**.
   b. Top Width: 4 inches (102 mm) **OR** 5 inches (127 mm) **OR** 6 inches (152 mm), **as directed**.
   c. Face Height: 4 inches (102 mm) **OR** 6 inches (152 mm) **OR** 8 inches (203 mm), **as directed**.
   d. Total Height: 12 inches (305 mm) **OR** 16 inches (406 mm) **OR** 18 inches (457 mm), **as directed**.
   e. Top Finish: Sawed **OR** Thermal **OR** Bush hammered, **as directed**.
   f. Face Finish: Split **OR** Sawed **OR** Thermal **OR** Bush hammered, **as directed.**

F. Accessories
1. Cork Joint Filler: Preformed strips complying with ASTM D 1752, Type II.
2. Compressible Foam Filler: Preformed strips complying with ASTM D 1056, Grade 2A1.

G. Aggregate Setting-Bed Materials
1. Graded Aggregate for Sub-base: Sound, crushed stone or gravel complying with ASTM D 448 for Size No. 57 **OR** ASTM D 2940, sub-base material **OR** requirements in Division 31 Section "Earth Moving" for sub-base material, **as directed**.
2. Graded Aggregate for Base: Sound, crushed stone or gravel complying with ASTM D 448 for Size No. 8 **OR** ASTM D 2940, base material **OR** requirements in Division 31 Section "Earth Moving" for base course, **as directed**.
3. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33 for fine aggregate.
4. Stone Screenings for Leveling Course: Sound stone screenings complying with ASTM D 448 for Size No. 10.
5. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing No. 16 (1.18-mm) sieve and no more than 10 percent passing No. 200 (0.075-mm) sieve.
   a. Provide sand of color needed to produce required joint color.
6. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications; made from polyolefins or polyesters, with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
   a. Survivability: Class 2, AASHTO M 288.
   b. Apparent Opening Size: No. 60 (0.250-mm) sieve, maximum; ASTM D 4751.

c. Permittivity: 0.02 per second, minimum; ASTM D 4491.
d. UV Stability: 50 percent after 500 hours' exposure, ASTM D 4355.

7. Drainage Geotextile: Nonwoven needle-punched geotextile made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
   a. Survivability: Class 2, AASHTO M 288.
   b. Apparent Opening Size: No. 40 (0.425-mm) sieve, maximum; ASTM D 4751.
   c. Permittivity: 0.5 per second, minimum; ASTM D 4491.
   d. UV Stability: 50 percent after 500 hours' exposure, ASTM D 4355.
8. Herbicide: Commercial chemical for weed control, registered with the EPA. Provide in granular, liquid, or wettable powder form.

H. Bituminous Setting-Bed Materials
1. Primer for Base: ASTM D 2028, cutback asphalt, grade as recommended by unit paver manufacturer.
2. Fine Aggregate for Setting Bed: ASTM D 1073, No. 2 or No. 3.
3. Asphalt Cement: ASTM D 3381, Viscosity Grade AC-10 or Grade AC-20.
4. Neoprene-Modified Asphalt Adhesive: Paving manufacturer's standard adhesive consisting of oxidized asphalt combined with 2 percent neoprene and 10 percent long-fibered mineral fibers containing no asbestos.
5. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing No. 16 (1.18-mm) sieve and no more than 10 percent passing No. 200 (0.075-mm) sieve.
   a. Provide sand of color needed to produce required joint color.

I. Mortar Setting-Bed Materials
1. Portland Cement: ASTM C 150, Type I or II.
2. Hydrated Lime: ASTM C 207, Type S.
3. Sand: ASTM C 144.
4. Latex Additive: Manufacturer's standard, acrylic resin or styrene-butadiene-rubber water emulsion, **as directed** serving as replacement for part or all of gaging water, of type specifically recommended by latex-additive manufacturer for use with field-mixed portland cement and aggregate mortar bed, and not containing a retarder.
5. Thinset Mortar: Latex-modified portland cement mortar complying with ANSI A118.4.
   a. Provide prepackaged, dry-mortar mix containing dry, redispersible, vinyl acetate or acrylic additive to which only water must be added at Project site.
   b. Provide prepackaged, dry-mortar mix combined with acrylic resin or styrene-butadiene-rubber liquid-latex additive at Project site, as directed.
6. Water: Potable.
7. Reinforcing Wire Fabric: Galvanized, welded wire fabric, 2-by-2-inch (51-by-51-mm) by 0.062-inch- (1.57-mm-) diameter wire; comply with ASTM A 1064/A 1064M and ASTM A 82/A 82M except for minimum wire size.

J. Grout Materials
1. Sand-Portland Cement Grout: ANSI A108.10, composed of white or gray cement, unfading mineral pigments and white or colored sand as required to produce required color.
   a. Colored Mortar Pigments for Grout: Natural and synthetic iron and chromium oxides, compounded for use in mortar and grout mixes. Use only pigments that have proved, through testing and experience, to be satisfactory for use in portland cement grout.
2. Standard Cement Grout: ANSI A118.6, sanded.
3. Polymer-Modified Grout: ANSI A118.7, sanded grout; in color indicated.
   a. Polymer Type: Ethylene-vinyl acetate or acrylic additive in dry, redispersible form; prepackaged with other dry ingredients.
   b. Polymer Type: Acrylic resin or styrene-butadiene rubber in liquid-latex form for addition to prepackaged dry-grout mix.
4. Grout Colors: As selected from manufacturer's full range.
5. Water: Potable.

K. Bituminous Setting-Bed Mix
1. Mix bituminous setting-bed materials at an asphalt plant in approximate proportion, by weight, of 7 percent asphalt cement to 93 percent fine aggregate, unless otherwise indicated. Heat mixture to 300 deg F (149 deg C).

L. Mortar And Grout Mixes
1. General: Comply with referenced standards and with manufacturers' written instructions. Discard mortars and grout if they have reached their initial set before being used.
2. Mortar-Bed Bond Coat: Mix neat cement or cement and sand with latex additive **OR** water, **as directed,** to a creamy consistency.
3. Portland Cement-Lime Setting-Bed Mortar: Type M complying with ASTM C 270, Proportion Specification.
4. Latex-Modified, Portland Cement Setting-Bed Mortar: Proportion and mix portland cement, sand, and latex additive for setting bed to comply with written instructions of latex-additive manufacturer and as necessary to produce stiff mixture with a moist surface when bed is ready to receive pavers.
5. Latex-Modified, Portland Cement Slurry Bond Coat: Proportion and mix portland cement, aggregate, and liquid latex for bond coat to comply with written instructions of liquid-latex manufacturer.
6. Thinset Mortar Bond Coat: Proportion and mix thinset mortar ingredients according to manufacturer's written instructions.
7. Job-Mixed Portland Cement Grout: Proportion and mix job-mixed portland cement and aggregate grout to match setting-bed mortar except omit hydrated lime and use enough water to produce a pourable mixture.
   a. Pigmented Grout: Select and proportion pigments with other ingredients to produce color required. Do not exceed pigment-to-cement ratio of 1:10, by weight.
   b. Colored-Aggregate Grout: Produce color required by combining colored sand with portland cement of selected color.
8. Package Grout Mix: Proportion and mix grout ingredients according to grout manufacturer's written instructions.

1.3 EXECUTION

A. Examination
1. Examine areas indicated to receive paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.
2. Where pavers are to be installed over waterproofing, examine waterproofing installation, with waterproofing Installer present, for protection from paving operations, including areas where waterproofing system is turned up or flashed against vertical surfaces.
3. Proceed with installation only after unsatisfactory conditions have been corrected and waterproofing protection is in place.

B. Preparation
1. Remove substances from concrete substrates that could impair mortar bond, including curing and sealing compounds, form oil, and laitance.
2. Sweep concrete substrates to remove dirt, dust, debris, and loose particles.
3. Proof-roll prepared subgrade according to requirements in Division 31 Section "Earth Moving" to identify soft pockets and areas of excess yielding. Proceed with unit paver installation only after deficient subgrades have been corrected and are ready to receive subbase and base course for unit pavers.

C. Installation, General
1. Do not use unit pavers with chips, cracks, voids, discolorations, or other defects that might be visible or cause staining in finished work.

2. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.
3. Cut unit pavers with motor-driven masonry saw equipment to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible.
   a. For concrete pavers, a block splitter may be used.
4. Handle protective-coated brick pavers to prevent coated surfaces from contacting backs or edges of other units. If, despite these precautions, coating does contact bonding surfaces of brick, remove coating from bonding surfaces before setting brick.
5. Joint Pattern: Running bond **OR** Herringbone **OR** Basket weave **OR** Match and continue existing unit paver joint pattern, **as directed**.
6. Pavers over Waterproofing: Exercise care in placing pavers and setting materials over waterproofing so protection materials are not displaced and waterproofing is not punctured or otherwise damaged. Carefully replace protection materials that become displaced and arrange for repair of damaged waterproofing before covering with paving.
   a. Provide joint filler at waterproofing that is turned up on vertical surfaces, unless otherwise indicated; where unfilled joints are indicated, provide temporary filler or protection until paver installation is complete.
7. Tolerances: For smooth pavers where slopes to drains are critical. Do not exceed 1/32-inch (0.8-mm) unit-to-unit offset from flush (lippage) nor 1/8 inch in 10 feet (3 mm in 3 m) from level, or indicated slope, for finished surface of paving.
   OR
   Tolerances: For smooth, flat pavers. Do not exceed 1/16-inch (1.6-mm) unit-to-unit offset from flush (lippage) nor 1/8 inch in 24 inches (3 mm in 600 mm) and 1/4 inch in 10 feet (6 mm in 3 m) from level, or indicated slope, for finished surface of paving.
8. Expansion and Control Joints: Provide for sealant-filled joints at locations and of widths indicated. Provide compressible foam filler as backing for sealant-filled joints unless otherwise indicated; where unfilled joints are indicated, provide temporary filler until paver installation is complete. Install joint filler before setting pavers. Sealant materials and installation are specified in Division 07 Section "Joint Sealants".
   OR
   Expansion and Control Joints: Provide cork joint filler at locations and of widths indicated. Install joint filler before setting pavers. Make top of joint filler flush with top of pavers.
9. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.
   a. Install edge restraints to comply with manufacturer's written instructions. Install stakes at intervals required to hold edge restraints in place during and after unit paver installation.
   b. For metal edge restraints with top edge exposed, drive stakes at least 1 inch (25 mm) below top edge.
   c. Install job-built concrete edge restraints to comply with requirements in Division 03 Section "Cast-in-place Concrete".
   d. Where pavers set in mortar bed are indicated as edge restraints for pavers set in aggregate setting bed, install pavers set in mortar and allow mortar to cure before placing aggregate setting bed and remainder of pavers. Cut off mortar bed at a steep angle so it will not interfere with aggregate setting bed.
   e. Where pavers embedded in concrete are indicated as edge restraints for pavers set in aggregate setting bed, install pavers embedded in concrete and allow concrete to cure before placing aggregate setting bed and remainder of pavers. Hold top of concrete below aggregate setting bed.
10. Provide steps made of pavers as indicated. Install paver steps before installing adjacent pavers.
    a. Where pavers set in mortar bed are indicated for steps constructed adjacent to pavers set in aggregate setting bed, install steps and allow mortar to cure before placing aggregate setting bed and remainder of pavers. Cut off mortar bed at a steep angle so it will not interfere with aggregate setting bed.

D. Aggregate Setting-Bed Applications
   1. Compact soil subgrade uniformly to at least 95 percent of ASTM D 698 **OR** ASTM D 1557, **as directed,** laboratory density.

2. Proof-roll prepared subgrade to identify soft pockets and areas of excess yielding. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined, and replace with compacted backfill or fill as directed.
3. Place separation geotextile over prepared subgrade, overlapping ends and edges at least 12 inches (300 mm).
4. Place aggregate subbase and base **OR** base, **as directed.**
   a. For light-traffic compact by tamping with plate vibrator, and screed to depth indicated.
   b. For heavy duty compact to 100 percent of ASTM D 1557 maximum laboratory density, and screed to depth indicated.
5. Place drainage geotextile over compacted base course, overlapping ends and edges at least 12 inches (300 mm).
6. Place leveling course and screed to a thickness of 1 to 1-1/2 inches (25 to 38 mm), taking care that moisture content remains constant and density is loose and constant until pavers are set and compacted.
7. Treat leveling course with herbicide to inhibit growth of grass and weeds.
8. Set pavers with a minimum joint width of 1/16 inch (1.5 mm) and a maximum of 1/8 inch (3 mm), being careful not to disturb leveling base. If pavers have spacer bars, place pavers hand tight against spacer bars. Use string lines to keep straight lines. Fill gaps between units that exceed 3/8 inch (10 mm) with pieces cut to fit from full-size unit pavers.
   a. When installation is performed with mechanical equipment, use only unit pavers with spacer bars on sides of each unit.
9. Vibrate pavers into leveling course with a low-amplitude plate vibrator capable of a 3500- to 5000-lbf (16- to 22-kN) compaction force at 80 to 90 Hz. Use vibrator with neoprene mat on face of plate or other means as needed to prevent cracking and chipping of pavers. Perform at least three passes across paving with vibrator.
   a. Compact pavers when there is sufficient surface to accommodate operation of vibrator, leaving at least 36 inches (900 mm) of uncompacted pavers adjacent to temporary edges.
   b. Before ending each day's work, compact installed concrete pavers except for 36-inch (900 mm) width of uncompacted pavers adjacent to temporary edges (laying faces).
   c. As work progresses to perimeter of installation, compact installed pavers that are adjacent to permanent edges unless they are within 36 inches (90 mm) of laying face.
   d. Before ending each day's work and when rain interrupts work, cover pavers that have not been compacted and cover leveling course on which pavers have not been placed with nonstaining plastic sheets to protect them from rain.
10. Spread dry sand and fill joints immediately after vibrating pavers into leveling course. Vibrate pavers and add sand until joints are completely filled, then remove excess sand. Leave a slight surplus of sand on the surface for joint filling.
11. Do not allow traffic on installed pavers until sand has been vibrated into joints.
12. Repeat joint-filling process 30 days later.

E. Bituminous Setting-Bed Applications
1. Apply primer to concrete slab or binder course immediately before placing setting bed.
2. Prepare for setting-bed placement by locating 3/4-inch- (19-mm-) deep control bars approximately 11 feet (3.3 m) apart, to serve as guides for striking board. Adjust bars for accurate setting of paving units to finished grades indicated.
3. Place bituminous setting bed between control bars. Spread mix at a minimum temperature of 250 deg F (121 deg C). Strike setting bed smooth, firm, even, and not less than 3/4 inch (19 mm) thick. Add fresh bituminous material to low, porous spots after each pass of striking board. Carefully fill depressions that remain after removing depth-control bars.
   a. Roll setting bed with power roller to a nominal depth of 3/4 inch (19 mm). Adjust thickness as necessary to allow accurate setting of unit pavers to finished grades indicated. Complete rolling before mix temperature cools to 185 deg F (85 deg C).
4. Apply neoprene-modified asphalt adhesive to cold setting bed by squeegeeing or troweling to a uniform thickness of 1/16 inch (1.6 mm). Proceed with setting of paving units only after adhesive is tacky and surface is dry to touch.

5. Place pavers carefully by hand in straight courses, maintaining accurate alignment and uniform top surface. Protect newly laid pavers with plywood panels on which workers can stand. Advance protective panels as work progresses, but maintain protection in areas subject to continued movement of materials and equipment to avoid creating depressions or disrupting alignment of pavers. If additional leveling of paving is required, and before treating joints, roll paving with power roller after sufficient heat has built up in the surface from several days of hot weather.
6. Joint Treatment: Place unit pavers with hand-tight joints. Fill joints by sweeping sand over paved surface until joints are filled. Remove excess sand after joints are filled.

F. Mortar Setting-Bed Applications
1. Saturate concrete sub-base with clean water several hours before placing setting bed. Remove surface water about one hour before placing setting bed.
2. Apply mortar-bed bond coat over surface of concrete sub-base about 15 minutes before placing setting bed. Limit area of bond coat to avoid its drying out before placing setting bed. Do not exceed 1/16-inch (1.6-mm) thickness for bond coat.
3. Apply mortar bed over bond coat immediately after applying bond coat. Spread and screed to subgrade elevations required for accurate setting of pavers to finished grades indicated.
4. Place reinforcing wire over concrete sub-base, lapped at joints by at least one full mesh and supported so mesh becomes embedded in the middle of setting bed. Hold edges back from vertical surfaces approximately 1/2 inch (13 mm).
5. Place mortar bed with reinforcing wire fully embedded in middle of setting bed. Spread and screed setting bed to uniform thickness at subgrade elevations required for accurate setting of pavers to finished grades indicated.
6. Mix and place only that amount of mortar that can be covered with pavers before initial set. Cut back and discard setting-bed material that has reached initial set before placing pavers.
7. Wet brick pavers before laying if the initial rate of absorption exceeds 30 g/30 sq. in. (30 g/194 sq. cm) per minute when tested per ASTM C 67. Allow units to absorb water so they are damp but not wet at time of laying.
8. Place pavers before initial set of cement occurs. Immediately before placing pavers, apply uniform 1/16-inch- (1.5-mm-) thick, slurry bond coat to bed or to back of each paver.
9. Tamp or beat pavers with a wooden block or rubber mallet to obtain full contact with setting bed and to bring finished surfaces within indicated tolerances. Set each paver in a single operation before initial set of mortar; do not return to areas already set or disturb pavers for purposes of realigning finished surfaces or adjusting joints.
10. Spaced Joint Widths: Provide 3/8-inch (10-mm) **OR** 1/2-inch (13-mm) **OR** 3/4-inch (19-mm), **as directed,** nominal joint width with variations not exceeding plus or minus 1/16 inch (1.5 mm) **OR** 1/8 inch (3 mm) **OR** 3/16 inch (4.5 mm), **as directed**.
11. Grouted Joints: Grout paver joints complying with ANSI A108.10.
12. Grout joints as soon as possible after initial set of setting bed.
    a. Force grout into joints, taking care not to smear grout on adjoining surfaces.
    b. Clean pavers as grouting progresses by dry brushing or rubbing with dry burlap to remove smears before tooling joints.
    c. Tool exposed joints slightly concave when thumbprint hard.
    d. If tooling squeezes grout from joints, remove excess grout and smears by dry brushing or rubbing with dry burlap and tool joints again to produce a uniform appearance.
13. Cure grout by maintaining in a damp condition for seven days, unless otherwise recommended by grout or liquid-latex manufacturer.

G. Repairing, Pointing, And Cleaning
1. Remove and replace unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.
2. Pointing: During tooling of joints, enlarge voids or holes and completely fill with grout. Point joints at sealant joints to provide a neat, uniform appearance, properly prepared for sealant application.

3. Cleaning: Remove excess grout from exposed paver surfaces; wash and scrub clean.
   a. Remove temporary protective coating as recommended by coating manufacturer and as acceptable to paver and grout manufacturers.
   b. Do not allow protective coating to enter floor drains. Trap, collect, and remove coating material.

END OF SECTION 31 25 14 23

Task	Specification	Specification Description
31 25 14 23	01 56 26 00	Sediment Removal
31 25 14 23	31 25 14 13	Geosynthetic Fabric
31 25 14 23	01 56 26 00a	Erosion Control

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SECTION 31 25 14 26 - SILT FENCES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing of labor, material and equipment for the installation of silt fencing.

1.2 PRODUCTS

A. Materials
1. Fabricated Units
a. Posts: 36" long, 2" hardwood or "T" or "U" type steel.
b. Fence: Woven wire, 14-1/2 ga. 6-inch max. mesh opening.
c. Filter Cloth: MIRAFI 100X or approved equal.
2. Prefabricated Units
a. Envirofence by MIRAFI or approved equal.

1.3 EXECUTION

A. The Contractor shall provide and install silt fences as directed by the Owner. It shall be the Contractor's option to provide fabricated reinforced silt fence or prefabricated units, unless otherwise directed. In all installations, the bottom flap of filter cloth shall be firmly embedded into undisturbed or stabilized grade. Embedment shall resist pullout and prevent flow under the installation.

END OF SECTION 31 25 14 26

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Task	Specification	Specification Description
31 25 14 26	01 56 26 00	Sediment Removal
31 25 14 26	01 56 26 00a	Erosion Control

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SECTION 31 31 16 13 - TERMITE CONTROL

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for termite control. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Soil and wood treatment with termiticide.
b. Bait-station system.
c. Metal mesh barrier system.
d. Polymer sheet barrier system with termiticide.
e. Polymer barrier fittings with termiticide for installation around utility penetrations.

C. Submittals
1. Product Data: For each type of termite control product.
a. Include the EPA-Registered Label for termiticide products.
2. Qualification Data: For qualified Installer.
3. Product Certificates: For termite control products, from manufacturer.
4. Soil Treatment Application Report: After application of termiticide is completed, submit report for Owner's records and include the following:
a. Date and time of application.
b. Moisture content of soil before application.
c. Termiticide brand name and manufacturer.
d. Quantity of undiluted termiticide used.
e. Dilutions, methods, volumes used, and rates of application.
f. Areas of application.
g. Water source for application.
5. Wood Treatment Application Report: After application of termiticide is completed, submit report for Owner's records and include the following:
a. Date and time of application.
b. Termiticide brand name and manufacturer.
c. Quantity of undiluted termiticide used.
d. Dilutions, methods, volumes used, and rates of application.
e. Areas of application.
6. Bait-Station System Application Report: After installation of bait-station system is completed, submit report for Owner's records and include the following:
a. Location of areas and sites conducive to termite feeding and activity.
b. Plan drawing showing number and locations of bait stations.
c. Dated report for each monitoring and inspection occurrence indicating level of termite activity, procedure, and treatment applied before time of Final Completion.
d. Termiticide brand name and manufacturer.
e. Quantities of termiticide and nontoxic termite bait used.
f. Schedule of inspections for one year from date of Final Completion.
7. Polymer Sheet Barrier System with Termiticide Application Report: After installation of polymer sheet barrier system with termiticide is completed, submit report for Owner's records and include the following:
a. Plan drawing showing extent of sheet barrier and number and locations of each type of polymer barrier fitting.
b. Termiticide brand name and manufacturer.

c. Schedule of inspections for one year from date of Final Completion.

8. Polymer Barrier Fittings with Termiticide Application Report: After installation of polymer barrier fittings with termiticide is completed, submit report for Owner's records and include the following:
   a. Plan drawing showing number and locations of each type of polymer barrier fitting with termiticide.
   b. Termiticide brand name and manufacturer.
   c. Schedule of inspections for one year from date of Final Completion.
9. Warranties: Sample of special warranties.

D. Quality Assurance
1. Installer Qualifications: A specialist who is licensed according to regulations of authorities having jurisdiction to apply termite control treatment and products in jurisdiction where Project is located, and who employs workers trained and approved by manufacturer to install manufacturer's products.
2. Regulatory Requirements: Formulate and apply termiticides and termiticide devices according to the EPA-Registered Label.
3. Source Limitations: Obtain termite control products from single source.
4. Preinstallation Conference: Conduct conference at Project site.

E. Project Conditions
1. Environmental Limitations: To ensure penetration, do not treat soil that is water saturated or frozen. Do not treat soil while precipitation is occurring. Comply with requirements of the EPA-Registered Label and requirements of authorities having jurisdiction.
2. Coordinate soil treatment application with excavating, filling, grading, and concreting operations. Treat soil under footings, grade beams, and ground-supported slabs before construction.
3. Apply wood treatment after framing, sheathing, and exterior weather protection is completed but before electrical and mechanical systems are installed.
4. Install bait-station system during construction to determine areas of termite activity and after construction, including landscaping, is completed.
5. Install polymer sheet barrier system with termiticide prior to placing concrete slab reinforcement and pouring concrete and after installation and inspection of footings, foundations, and plumbing and electrical pipes and conduits.
6. Install polymer barrier fittings with termiticide around utility penetrations prior to pouring concrete and after installation and inspection of plumbing and electrical pipes and conduits, slab vapor barrier, and concrete slab reinforcement.

F. Warranty
1. Soil Treatment Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work, consisting of applied soil termiticide treatment, will prevent infestation of subterranean termites. If subterranean termite activity or damage is discovered during warranty period, re-treat soil and repair or replace damage caused by termite infestation.
   a. Warranty Period: Three **OR** Five, **as directed**, years from date of Final Completion.
2. Wood Treatment Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work, consisting of applied wood termiticide treatment, will prevent infestation of subterranean termites. If subterranean termite damage is discovered during warranty period, repair or replace damage caused by termite infestation and treat replacement wood.
   a. Warranty Period: 12 years from date of Final Completion.
3. Polymer Sheet Barrier System with Termiticide Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work, consisting of installation of polymer sheet barrier system with termiticide, will prevent infestation of subterranean termites. If subterranean termite activity or damage is discovered during warranty period, re-treat and repair or replace damage caused by termite infestation.
   a. Warranty Period: 10 years from date of Final Completion.

4. Polymer Barrier Fittings with Termiticide Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work, consisting of installation of polymer barrier fittings with termiticide, will prevent infestation of subterranean termites. If subterranean termite activity or damage is discovered during warranty period, re-treat and repair or replace damage caused by termite infestation.
   a. Warranty Period: Five years from date of Final Completion.

G. Maintenance Service
1. Continuing Service (as directed): Beginning at Final Completion, provide 12 months' continuing service including monitoring, inspection, and re-treatment for occurrences of termite activity. Provide a standard continuing service agreement. State services, obligations, conditions, terms for agreement period, and terms for future renewal options.

1.2 PRODUCTS

A. Soil Treatment
1. Termiticide: Provide an EPA-Registered termiticide, complying with requirements of authorities having jurisdiction, in an aqueous solution formulated to prevent termite infestation. Provide quantity required for application at the label volume and rate for the maximum termiticide concentration allowed for each specific use, according to product's EPA-Registered Label.
   a. Service Life of Treatment: Soil treatment termiticide that is effective for not less than three **OR** five, **as directed**, years against infestation of subterranean termites.

B. Wood Treatment
1. Borate: Provide an EPA-Registered borate temiticide, complying with requirements of authorities having jurisdiction, in an aqueous solution for spray application and a gel solution for pressure injection, formulated to prevent termite infestation in wood. Provide quantity required for application at the label volume and rate for the maximum diffusible borate concentration allowed for each specific use, according to product's EPA-Registered Label.

C. Bait-Station System
1. Provide bait stations based on the dimensions of building perimeter indicated on Drawings, according to manufacturer's EPA-Registered Label for product, manufacturer's written instructions, and the following:
   a. No fewer than one bait station per 8 linear feet (2.4 linear meters) **OR** 20 linear feet (6.1 linear meters), **as directed**.
   b. No fewer than one cluster of bait stations per 20 linear feet (6.1 linear meters), consisting of no fewer than three bait stations per cluster.

D. Metal Mesh Barrier System
1. Stainless-Steel Mesh: 0.025-by-0.018-inch (0.64-by-0.45-mm) mesh of 0.08-inch- (2.0-mm-) diameter, stainless-steel wire, Type 316.

E. Polymer Sheet Barrier System
1. Polymer Sheet: 16-mil- (0.40-mm-) thick, multilayered, laminated, polymer sheet with lambda-cyhalothrin termiticide sealed between two outer polymer layers.

F. Polymer Barrier Fittings
1. Pipe/Conduit Fitting: Integral 2-1/2-inch- (65-mm-) long polymer sleeve and 1-inch- (25-mm-) wide circular flange with lambda-cyhalothrin termiticide sealed between two outer polymer layers; with fasteners.
2. Tub Trap Fitting: Integral polymer boot and 23-by-23-inch (585-by-585-mm) flange with lambda-cyhalothrin termiticide sealed between two outer polymer layers; with fasteners.

1.3 EXECUTION

A. Examination
1. Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements for moisture content of soil per termiticide label requirements, interfaces with earthwork, slab and foundation work, landscaping, utility installation, and other conditions affecting performance of termite control.
2. Proceed with application only after unsatisfactory conditions have been corrected.

B. Preparation
1. General: Comply with the most stringent requirements of authorities having jurisdiction and with manufacturer's written instructions for preparation before beginning application of termite control treatment. Remove all extraneous sources of wood cellulose and other edible materials such as wood debris, tree stumps and roots, stakes, formwork, and construction waste wood from soil within and around foundations.
2. Soil Treatment Preparation: Remove foreign matter and impermeable soil materials that could decrease treatment effectiveness on areas to be treated. Loosen, rake, and level soil to be treated except previously compacted areas under slabs and footings. Termiticides may be applied before placing compacted fill under slabs if recommended in writing by termiticide manufacturer.
   a. Fit filling hose connected to water source at the site with a backflow preventer, complying with requirements of authorities having jurisdiction.

C. Application, General
1. General: Comply with the most stringent requirements of authorities having jurisdiction and with manufacturer's EPA-Registered Label for products.

D. Applying Soil Treatment
1. Application: Mix soil treatment termiticide solution to a uniform consistency. Provide quantity required for application at the label volume and rate for the maximum specified concentration of termiticide, according to manufacturer's EPA-Registered Label, to the following so that a continuous horizontal and vertical termiticidal barrier or treated zone is established around and under building construction. Distribute treatment evenly.
   a. Slabs-on-Grade and Basement Slabs: Under ground-supported slab construction, including footings, building slabs, and attached slabs as an overall treatment. Treat soil materials before concrete footings and slabs are placed.
   b. Foundations: Adjacent soil, including soil along the entire inside perimeter of foundation walls; along both sides of interior partition walls; around plumbing pipes and electric conduit penetrating the slab; around interior column footers, piers, and chimney bases; and along the entire outside perimeter, from grade to bottom of footing. Avoid soil washout around footings.
   c. Crawlspaces: Soil under and adjacent to foundations as previously indicated. Treat adjacent areas including around entrance platform, porches, and equipment bases. Apply overall treatment only where attached concrete platform and porches are on fill or ground.
   d. Masonry: Treat voids.
   e. Penetrations: At expansion joints, control joints, and areas where slabs will be penetrated.
2. Avoid disturbance of treated soil after application. Keep off treated areas until completely dry.
3. Protect termiticide solution, dispersed in treated soils and fills, from being diluted until ground-supported slabs are installed. Use waterproof barrier according to EPA-Registered Label instructions.
4. Post warning signs in areas of application.
5. Reapply soil treatment solution to areas disturbed by subsequent excavation, grading, landscaping, or other construction activities following application.

E. Applying Wood Treatment

1. Application: Mix wood treatment solution to a uniform consistency. Provide quantity required for application at the label volume and rate for the maximum specified concentration of borate, according to manufacturer's EPA-Registered Label, so that wood framing, sheathing, siding, and structural members subject to infestation receive treatment.
   a. Framing and Sheathing: Apply termiticide solution by spray to bare wood for complete coverage.
   b. Wood Members More Than 4 Inches (100 mm) Thick: Inject termiticide gel solution under pressure into holes of size and spacing required by manufacturer for treatment.
   c. Exterior Uncoated Wood Trim and Siding: Apply termiticide solution to bare wood siding. After 48 hours, apply a seal coat of paint as specified in Division 07.

F. Installing Bait-Station System
1. Place bait stations according to the EPA-Registered Label for the product and manufacturer's written instructions, in the following areas that are conducive to termite feeding and activity:
   a. Conducive sites and locations indicated on Drawings.
   b. In and around infested trees and stumps.
   c. In mulch beds.
   d. Where wood directly contacts soil.
   e. Areas of high soil moisture.
   f. Near irrigation sprinkler heads.
   g. Each area where roof drainage system, including downspouts and scuppers, drains to soil.
   h. Along driplines of roof overhangs without gutters.
   i. Where condensate lines from mechanical equipment drip or drain to soil.
   j. At plumbing penetrations through ground-supported slabs.
   k. Other sites and locations as determined by licensed Installer.
2. Inspect and service bait stations from time of their application until Final Completion unless extended by continuing service agreement, according to the EPA-Registered Label for product and manufacturer's written instructions for termite management system and bait products.
   a. Service Frequency: Inspect bait stations not less than once every **OR** every three, **as directed**, month(s).

G. Installing Metal Mesh Barrier System
1. Install metal mesh barrier system where indicated to provide a continuous barrier to entry of subterranean termites according to manufacturer's written instructions.
   a. Fit mesh tightly around pipe or other penetrations, and terminate at slab and foundation perimeters.
   b. Install mesh under the perimeter of concrete slab edges and joints after vapor barrier and reinforcing steel are in place, and comply with manufacturer's written installation methods.
2. Inspect annually for termite activity and effectiveness of metal mesh barrier system according to manufacturer's written instructions.

H. Installing Polymer Sheet Barrier System
1. Install polymer sheet barrier system according to manufacturer's EPA-Registered Label to provide a complete and continuous barrier to entry of subterranean termites.
2. Remove any pipe wrap material so that the polymer sheet barrier system and fittings can be applied directly to the pipe or conduit. After installing the barrier, reapply pipe wrap material both below and above the blocker to protect the pipe from contact with concrete.
3. Install polymer barrier fittings around each utility pipe and conduit penetrating concrete slab and/or foundation walls according to the EPA-Registered Label for the product and manufacturer's written instructions.

I. Installing Polymer Barrier Fittings
1. Remove any pipe wrap material so that the polymer barrier fittings can be applied directly to the pipe or conduit. After installing the barrier, reapply pipe wrap material both below and above the blocker to protect the pipe from contact with concrete.

2. Install polymer barrier fittings around each utility pipe and conduit penetrating concrete slab and/or foundation walls according to the EPA-Registered Label for the product and manufacturer's written instructions.

END OF SECTION 31 31 16 13

SECTION 31 31 19 13 - SOIL STERILIZATION

1.1 GENERAL

A. Description Of Work
1. This specification covers soil sterilization. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations.

1.2 PRODUCTS

A. Weed Eradication and Soil Fumigation: Products approved by the Environmental Protection Agency.

B. Liquid and Dry Herbicides:
1. Bare Ground Herbicides: Bromacil powder mixture or an ammonium sulfamate spray.
2. Wetting Agents: As required.

C. Equipment: Equipment shall be appropriate to the application and approved before use by the Owner.

1.3 EXECUTION

A. Soil: After the subgrade has been prepared, all areas to be surfaced shall be treated with a weed eradicator and soil fumigant only in the designated areas.

B. Wetting Agents may be used as an additive to improve the performance of weed and brush herbicides.

END OF SECTION 31 31 19 13

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SECTION 31 32 13 16 - SOIL STABILIZATION-LIME

1.1 GENERAL

A. Description Of Work
1. This specification covers furnishing of materials and the preparation and production of a stabilized subgrade by the addition of hydrated lime to the native material.

1.2 PRODUCTS

A. Hydrated lime material requirements shall be as follows:
1. Available Lime Index as Calcium Hydroxide: 90 percent minimum.
2. Residue retained on No. 30 Sieve: 1 percent maximum.
3. Residue retained on No. 200 Sieve: 20 percent maximum.

1.3 EXECUTION:

A. Preparation: Scarify the subgrade to the depth required and pulverize the material until it is substantially free of lumps greater than three inches in diameter.

B. Installation: Lime shall be applied to the pulverized material as a slurry, unless otherwise directed. Water shall be added as needed to provide a moisture content of not less than 20 percent. Surface-applied lime slurry shall be plowed and/or disked into the soil as necessary. The resulting mixture shall be aged for not less than 48 hours before compaction.

END OF SECTION 31 32 13 16

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SECTION 31 32 13 19 - SOIL STABILIZATION-VIBROFLOTATION

1.1 GENERAL

A. This specification covers soil stabilization of sandy subsurfaces by the method of vibroflotation.

1.2 PRODUCTS - (Not Used)

1.3 EXECUTION

A. The vibroflotation process shall be applied only to areas of clean, granular soils, with not over 20 percent silt or 10 percent clay. Vibrators shall be water-jetted into the soil mass to the depth required. The vibrator shall be withdrawn in 1 foot increments as the saturated soil compacts laterally and at a rate of approximately 1 ft/min to a minimum relative density of 70 percent. As the surface crater forms, sand or crushed rock shall be added and compacted to the appropriate line and grade. The horizontal distance between successive treatments shall not exceed 5 feet, or as directed.

END OF SECTION 31 32 13 19

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Task	Specification	Specification Description
31 32 13 19	31 32 13 16	Soil Stabilization-Lime
31 32 13 29	31 32 13 16	Soil Stabilization-Lime
31 32 19 13	31 32 13 16	Soil Stabilization-Lime
31 32 19 13	31 25 14 13	Geosynthetic Fabric

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SECTION 31 32 19 16 - SEWAGE TREATMENT LAGOONS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for the repair and maintenance of sewage treatment lagoons. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Materials
1. Concrete Block shall comply with ASTM C 129.
2. Concrete Grout shall comply with Fed. Spec. MMM-A-001993.
3. Riprap Stone shall comply with AREA-01.
4. Concrete Repair Material shall comply with Fed. Spec. MMM-A-001993.
5. Sand shall comply with ASTM C 33.
6. Portland Cement shall comply with ASTM C 150, Type V.
7. Rubble shall consist of broken concrete or broken stone.

1.3 EXECUTION

A. Algae Removal shall be by mechanical or manual methods and shall include, but not be limited to, skimming, pumping through a screen, raking, or draining and cleaning the lagoon.

B. Slope and Dike Reconstruction shall be made to re-establish the original design configuration and grades. Place riprap, where required, so that its angle of repose is not exceeded.

C. Liner Reconstruction and Repair shall be made with materials compatible with the existing liner and compatible with the wastewater and sludge to be contained therein.

D. Repairs to Elastomeric Membrane Liners shall be made with like material and shall overlap all cuts, tears, fractures or other defects a minimum of 4 inches. Cut repair pieces square or rectangular. The method of bonding the new material to existing material shall be similar to the original joint banding method, except when the original joints have failed. In this case, the material supplier shall demonstrate that an alternate jointing system shall be satisfactory to the Owner. Replace earth or sand cover removed during repair or replacement of plastic liner to the same thickness as the original installation.

E. Repairs to Non-Elastomeric Membrane Liners shall be made by cutting out defective areas back to sound liner material and replacing with similar material. Joints shall be watertight.

END OF SECTION 31 32 19 16

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SECTION 31 32 19 16a - POND RESERVOIR LINERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for pond and reservoir liners. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes geomembrane liners and floating covers for ponds and reservoirs.

C. Definitions
1. Plastics Terminology: See ASTM D 1600 for definitions of abbreviated terms for plastics not otherwise defined in this Section.
2. CSPE: Chlorosulfonated polyethylene.
3. EIA: Ethylene interpolymer alloy.
4. EPDM: Ethylene-propylene-diene terpolymer.
5. PE: Polyethylene.
6. PP: Polypropylene.

D. Performance Requirements
1. Provide geomembrane liners and floating covers, **as directed**, that prevent the passage of water and gas, **as directed**.

E. Submittals
1. Product Data: For each type of product indicated. Include the following:
   a. Sheets for geomembrane liners and floating covers.
   b. Seaming adhesives, solvents, and extrusions.
   c. Penetration assemblies.
   d. Accessories for floating covers.
2. Shop Drawings: Show fabrication and installation details for geomembrane liners. Show panel layout, seams, penetrations, perimeter anchorage, floating cover, and methods of attachment and sealing to other construction. Differentiate between factory and field seams and joints.
3. Samples: For the following products, in sizes indicated:
   a. Geomembrane Panels: For each type, not less than one 12-inch (300-mm) seam length for factory-bonded sheets and one 12-inch (300-mm) seam length for field-bonded sheets.
4. Qualification Data: For qualified Installer **OR** testing agency, **as directed**.
5. Product Certificates: For each type of geomembrane liner and floating cover, from manufacturer.
6. Product Test Reports: For each geomembrane sheet, based on evaluation of comprehensive tests performed by a qualified testing agency.
7. Source quality-control reports.
8. Field quality-control reports.
9. Maintenance Data: For geomembrane liner and floating cover to include in maintenance manuals.
10. Warranty: Special warranty specified in this Section.

F. Quality Assurance
1. Installer Qualifications: Fabricator of products **OR** An employer of workers trained and approved by manufacturer, **as directed**.
2. Source Limitations: Obtain geomembrane liner and floating cover, accessories, and required seaming materials, solvents, and adhesives from single source.
3. Preinstallation Conference: Conduct conference at Project site.

a. Inspect and discuss condition of substrate and other preparatory work performed by other trades.
b. Review structural load limitations.
c. Review limitations on equipment and Installer's personnel.
d. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
e. Review required testing, inspecting, and certifying procedures.
f. Review existing and forecasted weather conditions and procedures for unfavorable conditions.

G. Project Conditions
1. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit placement and seaming of geomembrane liners and floating covers to be performed according to manufacturers' written instructions and warranty requirements.

H. Warranty
1. Special Warranty: Specified form in which geomembrane manufacturer, geomembrane liner and floating cover fabricator, and geomembrane liner and floating cover Installer agree to repair or replace geomembrane liner and floating cover that fail(s) in materials or workmanship or that deteriorate(s) under conditions of normal weather within specified warranty period. Warranty does not include deterioration or failure of geomembrane liner and floating cover due to exposure to harmful chemicals, gases or vapors, abnormal and severe weather phenomena, fire, earthquakes, floods, vandalism, or abuse by persons, animals, or equipment.
a. Failures include, but are not limited to, the following:
1) Leaks in geomembrane liner and floating cover.
2) Defects in seams.
3) Cracks and holes in floating cover.
b. Warranty Period: One **OR** Five **OR** 10, **as directed**, year(s) from date of Final Completion.

1.2 PRODUCTS

A. CSPE Sheet Materials
1. CSPE Sheet: Formulated from CSPE for use in hydraulic structures and formed into uniform, flexible sheets.
a. Reinforcing Scrim: One-ply polyester fabric totally encapsulated between two sheets.
1) Construction: 6 x 6 - 1000 d **OR** 8 x 8 - 250 d **OR** 10 x 10 - 1000 d, **as directed**.
b. Nominal Thickness: 45-mil- (1.14-mm-) thick sheet per ASTM D 5199 or ASTM D 751, Optical Method.
c. Nominal Thickness over Scrim: 11-mil- (0.28-mm-) thick sheet per ASTM D 5199 or ASTM D 751, Optical Method.
d. Breaking Strength: Not less than 200 lbf (0.89 kN) minimum average per ASTM D 751, Procedure A.
e. Tear Strength, Initial: Not less than 70 lbf (0.31 kN) minimum average per ASTM D 5884 or ASTM D 751, Procedure B.
f. Tear Strength, after Aging: Not less than 35 lbf (0.16 kN) minimum average per ASTM D 5884 or ASTM D 751, Procedure B.
g. Puncture Resistance: Not less than 200 lbf (0.89 kN) minimum average per ASTM D 4833.
h. Hydrostatic Resistance: Not less than 250-psi (1725-kPa) minimum average resistance per ASTM D 5514, Procedure A or ASTM D 751, Method A, Procedure 1.
i. Dimensional Stability, Reinforced Sheet: Not more than plus or minus 2 percent per ASTM D 1204.
j. Low-Temperature Flexibility: Pass, 1/8-inch (3-mm) mandrel, four hours at minus 40 deg F (minus 40 deg C), and per ASTM D 2136.

k. UV-Light Resistance: Pass, 4000 hours at 176 deg F (80 deg C), per ASTM G 155.
l. Ply Adhesion: Not less than 7 lbf/in. (1.2 kN/m) **OR** 10 lbf/in. (1.75 kN/m), **as directed**, of seam width, or film tearing bond, according to ASTM D 413, Machine Method.
m. Water Absorption (for low-water-absorption CSPE): Not more than 2 percent at 70 deg F (21 deg C) and not more than 30 percent at 158 deg F (70 deg C) for 30 days each per ASTM D 471, 30-mil- (0.76-mm-) thick sheet.

B. EIA Sheet Materials
1. EIA Sheet: Formulated from EIA for use in hydraulic structures and formed into uniform, flexible sheets.
a. Reinforcing Scrim: One-ply polyester fabric totally encapsulated between two sheets.
1) Construction: 6 x 6 - 1000 d **OR** 8 x 8 - 500 d **OR** 10 x 10 - 1000 d **OR** 10 x 11 - 2520 d x 2000 d, **as directed**.
b. Nominal Thickness: 36-mil- (0.91-mm-) thick sheet per ASTM D 1593 or ASTM D 751, Optical Method.
c. Tensile Strength: Not less than 400 lbf (1.8 kN) minimum average per ASTM D 751, Procedure A.
d. Tear Strength: Not less than 35 lbf (0.16 kN) minimum average per ASTM D 5884 or ASTM D 751, Procedure B.
e. Puncture Resistance: Not less than 150 lbf (0.67 kN) minimum average per ASTM D 4833.
f. Hydrostatic Resistance: Not less than 100-psi (690-kPa) minimum average resistance per ASTM D 751, Procedure A.
g. Dimensional Stability, Reinforced Sheet: Not more than plus or minus 2 percent per ASTM D 1204.
h. Low-Temperature Flexibility: Pass, 1/8-inch (3-mm) mandrel, four hours at minus 30 deg F (minus 34 deg C), and per ASTM D 2136.
i. UV-Light Resistance: Pass, 4000 hours at 176 deg F (80 deg C), per ASTM G 155.
j. Ply Adhesion: Not less than 7 lbf/in. (1.2 kN/m) **OR** 10 lbf/in. (1.75 kN/m), **as directed**, of seam width, or film tearing bond, according to ASTM D 413, Machine Method.

C. EPDM Sheet Materials
1. EPDM Sheet: Formulated from EPDM, compounded for use in hydraulic structures and formed into uniform, flexible sheets.
a. Reinforcing Scrim: One-ply polyester fabric totally encapsulated between two sheets.
1) Construction: 9 x 9 - 1000 d **OR** 10 x 10 - 1000 d, **as directed**.
b. Nominal Thickness: 45-mil- (1.14-mm-) thick sheet per ASTM D 5199 or ASTM D 751, Optical Method.
c. Breaking Strength: Not less than 190 lbf (0.85 kN) minimum average per ASTM D 882, ASTM D 7004, or ASTM D 751, Procedure A.
d. Tear Resistance: Not less than 130 lb (0.58 kN) minimum average per ASTM D 1004.
e. Puncture Strength: Not less than 60 lbf (0.27 kN) minimum average per ASTM D 4833.

D. PE Sheet Materials
1. PE Sheet: Formulated from virgin PE, compounded for use in hydraulic structures, and formed into uniform sheets.
a. Sheet Texture: One side smooth; other side smooth **OR** textured, **as directed**.
b. Nominal Density: Low density, 0.910 to 0.925 g/cu. cm **OR** Linear low density, 0.919 to 0.925 g/cu. cm **OR** Medium density, 0.926 to 0.939 g/cu. cm **OR** High density, 0.940 to 0.959 g/cu. Cm, **as directed**, per ASTM D 1505.
c. Nominal Thickness: 60-mil- (1.5-mm-) thick sheet per ASTM D 5199 **OR** ASTM D 5994, **as directed**.
d. Melt Flow Index: Not more than 0.035 oz./10 minutes (1.0 g/10 minutes) per ASTM D 1238, Condition 190/2.16.
e. Carbon Black Content: 2 to 3 percent per ASTM D 1603 or ASTM D 4218.
f. Carbon Black Dispersion: Per ASTM D 5596, Category 1 and 2.

g. Oxidation Induction Time: Not less than 100 minutes per ASTM D 3895.
h. Tensile Properties: Not less than indicated for each direction, per ASTM D 638, Type IV or ASTM D 6693, Type IV.
   1) Strength at Yield: Not less than 126 lbf/in. (22 kN/m) and 2100 psi (14.5 MPa) minimum average.
   2) Strength at Break: Not less than 228 lbf/in. (40 kN/m) and 3800 psi (26.2 MPa) minimum average.
   3) Elongation at Yield: Not less than 12 percent minimum average.
   4) Elongation at Break: Not less than 700 percent minimum average.
i. Tear Resistance: Not less than 39 lbf (0.18 kN) minimum average per ASTM D 1004.
j. Puncture Resistance: Not less than 108 lbf (0.48 kN) minimum average per ASTM D 4833.
k. Dimensional Stability, Reinforced Sheet: Not more than plus or minus 2 percent per ASTM D 1204.
l. Low-Temperature Brittleness: Four hours at minus 76 deg F (minus 60 deg C) per ASTM D 746.
m. Environmental Stress Cracking Resistance: Not less than 1500 hours per ASTM D 1693, Condition B.

E. PP Sheet Materials
1. PP Sheet: Formulated from virgin PP, compounded for use in hydraulic structures, and formed into uniform, flexible sheets.
   a. Reinforcing Scrim: One-ply polyester fabric totally encapsulated between two sheets.
      1) Construction: 9 x 9 - 1000 d **OR** 10 x 10 - 1000 d, **as directed**.
   b. Sheet Texture: One side smooth; other side smooth **OR** textured, **as directed**.
   c. Nominal Thickness: 45-mil- (1.14-mm-) thick sheet per ASTM D 5199 or ASTM D 751, Optical Method **OR** ASTM D 5994, **as directed**.
   d. Tensile Strength: Not less than 250 lbf (1.1 kN) minimum average per ASTM D 412, ASTM D 7003, ASTM D 6693, or ASTM D 751, Procedure A.
   e. Tear Resistance: Not less than 55 lbf (0.24 kN) minimum average per ASTM D 1004, ASTM D 5884, ASTM D 7003, or ASTM D 751, Procedure B.
   f. Puncture Resistance: Not less than 200 lbf (0.88 kN) minimum average per ASTM D 4833 or ASTM D 7003.
   g. Low-Temperature Flexibility: Pass, 1/8-inch (3-mm) mandrel, four hours at minus 40 deg F (minus 40 deg C), and per ASTM D 2136.
   h. Hydrostatic Resistance: Not less than 250-psi (1725-kPa) minimum average resistance per ASTM D 5514, Procedure A or ASTM D 751, Method A, Procedure 1.
   i. Dimensional Stability, Reinforced Sheet: Not more than plus or minus 1 percent per ASTM D 1204.
   j. Ply Adhesion: Not less than 20 lbf/in. (3.5 kN/m) of seam width, or film tearing bond, according to ASTM D 413, Machine Method.

F. PVC Sheet Materials
1. PVC Sheet: Formulated from virgin PVC with plasticizers and other modifiers, compounded for use in hydraulic structures, and formed into uniform, flexible sheets with material properties complying with ASTM D 7176 **OR** PGI 1104, "Specification for PVC Geomembranes", **as directed**, for nominal thickness indicated.
   a. Nominal Thickness: 10 mils (0.25 mm) **OR** 20 mils (0.51 mm) **OR** 30 mils (0.76 mm) **OR** 40 mils (1.02 mm) **OR** 50 mils (1.3 mm) **OR** 60 mils (1.5 mm), **as directed**.
   b. Sheet Texture: One side smooth; other side smooth **OR** matte **OR** faille textured, **as directed**.

G. Floating Cover Accessories
1. Screened Scupper Hoses: Manufacturer's standard.

2. Flotation Blocks: Closed-cell polyethylene foam blocks approximately 4 by 12 inches (102 by 300 mm), 2.2 lb/cu. ft. (35.2 kg/cu. m).
3. Access Hatch: Manufacturer's standard, in size indicated.

H. Miscellaneous Materials
1. Adhesives: Provide types of adhesive primers, compounds, solvents, and tapes recommended in writing by geomembrane liner manufacturer for bonding to structures (if required), for sealing of seams in geomembrane liner, and for sealing penetrations through geomembrane liner.
2. Penetration Assemblies: Provide manufacturer's standard factory-fabricated assemblies for sealing penetrations. Include joint sealant recommended in writing by geomembrane liner manufacturer and compatible with geomembrane liner, containment conditions, and materials.
3. Battens: Long-length strips of material indicated, size as shown on Drawings. Fabricate battens with sharp projections removed and edges eased and then predrilled or punched for anchors. Provide anchors, or other type of attachment, of type and spacing recommended in writing by geomembrane liner manufacturer for attaching geomembrane liner system to substrate and as indicated.
   a. Batten Material: Liner manufacturer's standard system.
      OR
      Batten Material: Aluminum; with stainless-steel anchors, complete with gasket and sealant compatible with geomembrane liner, containment conditions, and materials.
      OR
      Batten Material: Stainless steel; with stainless-steel anchors, complete with gasket and sealant compatible with geomembrane liner, containment conditions, and materials.
      OR
      Batten Material: Plastic compatible with geomembrane liner, cast in place or fastened with stainless-steel anchors, designed to continuously seal geomembrane liner to batten.
4. Sand: ASTM C 33; fine aggregate, natural or manufactured sand.

I. Fabrication
1. Fabricate geomembrane liner and floating cover, **as directed**, panels from sheets in sizes as large as possible with factory-sealed seams, consistent with limitations of weight and installation procedures. Minimize field seaming.
2. Fabricate flotation blocks, wrap in geomembrane, and attach to underside of floating cover according to manufacturer's written instructions.
3. Fabricate ballast tubes of sand-filled geomembrane and attach to top surface of floating cover according to manufacturer's written instructions.
4. Install built-in accessories, hatches, access panels, vents, and walkways on geomembrane floating cover.

J. Source Quality Control
1. Testing Agency: Engage a qualified testing agency to evaluate geomembrane seams.
2. Destructive Testing: Test for bonded seam strength and peel adhesion every 3000 feet (915 m) or once per panel, whichever is more frequent.
3. CSPE Liner and Floating Cover: Test and inspect factory seams, according to ASTM D 4545, for peel adhesion not less than 10 lbf/in. (1.75 kN/m) of seam width and for bonded seam strength not less than 180 lbf/in. (32 kN/m) of seam width for seams constructed from two scrim-reinforced sheets, each with nominal sheet thickness of not less than 45 mils (1.14 mm).
4. EIA Liner and Floating Cover: Test and inspect factory seams, according to ASTM D 4545, for peel adhesion not less than 10 lbf/in. (1.75 kN/m) of seam width and for bonded seam strength not less than 270 lbf/in. (48 kN/m) of seam width for seams constructed from two scrim-reinforced sheets, each with nominal sheet thickness of not less than 36 mils (0.91 mm).
5. EPDM Liner: Test and inspect factory seams, according to ASTM D 4545, for peel adhesion not less than 10 lbf/in. (1.75 kN/m) of seam width and for bonded seam strength not less than 160 lbf/in. (28 kN/m) of seam width for seams constructed from two scrim-reinforced sheets, each with nominal sheet thickness of not less than 45 mils (1.14 mm).

6. PE Liner: Test and inspect factory seams, according to ASTM D 4545, for peel adhesion and for bonded seam strength indicated.
   a. Peel Adhesion/Extrusion: Film tear bond and not less than 78 lbf/in. (13.7 kN/m) of extrusion-bonded seam width.
      OR
      Peel Adhesion/Fusion: Film tear bond and not less than 90 lbf/in. (15.8 kN/m) of fused seam width.
   b. Bonded Seam Strength: Not less than 120 lbf/in. (21 kN/m) of seam width for seams constructed from two scrim-reinforced sheets, each with nominal sheet thickness of not less than 45 mils (1.14 mm).
7. PP Liner and Floating Cover: Test and inspect factory seams, according to ASTM D 4545, for peel adhesion not less than 20 lbf/in. (3.5 kN/m) of seam width and for bonded seam strength not less than 200 lbf/in. (35 kN/m) of seam width for seams constructed from two scrim-reinforced sheets, each with nominal sheet thickness of not less than 45 mils (1.14 mm).
8. PVC Liner and Floating Cover: Test and inspect factory seams, according to ASTM D 4545, for peel adhesion not less than 10 lbf/in. (1.75 kN/m) of seam width and for bonded seam strength not less than that indicated below for seams constructed from two sheets of minimum nominal thickness indicated for each:
   a. Bonded Seam Strength for 10-mil- (0.25-mm-) Thick Sheets: 20 lbf/in. (3.5 kN/m) of seam width.
   b. Bonded Seam Strength for 20-mil- (0.51-mm-) Thick Sheets: 38.5 lbf/in. (6.7 kN/m) of seam width.
   c. Bonded Seam Strength for 30-mil- (0.76-mm-) Thick Sheets: 58.4 lbf/in. (10.2 kN/m) of seam width.
   d. Bonded Seam Strength for 40-mil- (1.02-mm-) Thick Sheets: 77.6 lbf/in. (13.6 kN/m) of seam width.
   e. Bonded Seam Strength for 50-mil- (1.3-mm-) Thick Sheets: 96 lbf/in. (16.8 kN/m) of seam width.
   f. Bonded Seam Strength for 60-mil- (1.5-mm-) Thick Sheets: 116 lbf/in. (20.3 kN/m) of seam width.

1.3 EXECUTION

A. Examination
   1. Examine substrates, with Installer present, for compliance with requirements for soil compaction and grading; for subgrade free from angular rocks, rubble, roots, vegetation, debris, voids, protrusions, and ground water; and for other conditions affecting performance of geomembrane liner.
   2. Examine anchor trench excavation **OR** concrete perimeter, **as directed,** where geomembrane liner and floating cover, **as directed**, will be secured, for substrate conditions indicated above and for correct location and configuration.
   3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation
   1. Provide temporary ballast, until edges are permanently secured, that does not damage geomembrane liner or substrate, to prevent uplift of geomembrane liner in areas with prevailing winds.
   2. Prepare surfaces of construction penetrating through geomembrane liner according to geomembrane liner manufacturer's written instructions.
   3. Remove curing compounds and coatings from concrete surfaces to be sealed to geomembrane liner.

C. Installation

1. General: Place geomembrane liner over prepared surfaces to ensure minimum handling. Install according to Shop Drawings and in compliance with geomembrane liner manufacturer's written instructions. Begin placing geomembrane liner at Project's upwind direction and proceed downwind. Install geomembrane liner in a relaxed condition, free from stress and with minimum wrinkles, and in full contact with subgrade. Do not bridge over voids or low areas in the subgrade. Fit closely and seal around inlets, outlets, and other projections through geomembrane liner. Permanently secure edges.
2. Field Seams: Comply with geomembrane liner and floating cover manufacturer's written instructions. Form seams by lapping edges of panels 2 to 4 inches (50 to 102 mm) unless instructions require a larger overlap. Wipe contact surfaces clean and free of dirt, dust, moisture, and other foreign materials. Use solvent-cleaning methods and grind geomembrane seam surfaces if recommended by geomembrane liner manufacturer. Proceed with seaming at required temperatures for materials and ambient conditions. Continuously bond sheet to sheet to construct single or double seams of width recommended for method of seaming used. Seal or fuse free seam edges. Inspect seams and reseal voids.
   a. Adhesive Bonding: Apply bonding cement to both contact surfaces in seam area and press together immediately, or use other seaming methods as instructed by geomembrane liner manufacturer. Roll to press surfaces together, to distribute adhesive to leading edges of panels, and to remove wrinkles and fishmouths. Remove excess adhesive.
      OR
      Thermal Bonding: Use thermal-welding technique recommended by geomembrane liner manufacturer. Apply pressure to smoothly bond surfaces together. Examine for and patch wrinkles and fishmouths.
3. Installation in Anchor Trench: Install geomembrane liner and floating cover in trench according to manufacturer's written instructions. Backfill and compact to lock liner into trench.
4. Attachment to Concrete: Use manufacturer's standard system to suit Project conditions. Support adhesive and geomembrane on minimum 8-inch- (200-mm-) wide concrete substrate unless otherwise indicated.
   a. Install batten strips over geomembrane liner and floating cover as shown on Drawings.
   b. Install antichafing strips of geomembrane sheet between geomembrane liner and floating cover according to manufacturer's written instructions.
   c. Install floating cover with perimeter fold.
5. Floating Cover Flotation Control: Connect drainage hoses in perimeter fold, sumps, or scuppers to pump or gravity drain system.
6. Liner Repairs: Repair tears, punctures, and other imperfections in geomembrane liner field and seams using patches of geomembrane liner material, liner-to-liner bonding materials, and bonding methods according to geomembrane liner manufacturer's written instructions. Apply bonding solvent or weld to contact surfaces of both patch and geomembrane liner, and press together immediately. Roll to remove wrinkles.

D. Field Quality Control
1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
2. Nondestructive Testing: Visually inspect seams and patches. Comply with ASTM D 4437 for Air Lance Test, Vacuum Box Testing, or Ultrasonic (High Frequency) Pulse Echo Testing or with GRI Test Method GM6, as applicable to geomembrane liner and floating cover and seam construction. Record locations of failed seams and patches. Individually number and date occurrences and details of leak and remedial action. Repair leaking seams and patches.
3. Prepare test and inspection reports.

E. Disinfection
1. Disinfect the complete installation according to procedures in AWWA C652.

F. Protection
1. Protect installed geomembrane liner and floating cover according to manufacturer's written instructions. Repair or replace areas of geomembrane liner damaged by scuffing, punctures, traffic, rough subgrade, or other unacceptable conditions.

2. Before initial filling of pond or placement of earth cover, inspect seams and patched areas to ensure tight, continuously bonded installation. Repair damaged geomembrane and seams and reinspect repaired work.

END OF SECTION 31 32 19 16a

Task	Specification	Specification Description
31 32 19 16	21 05 23 00	Piped Utilities Basic Materials And Methods
31 32 19 16	31 32 13 16	Soil Stabilization-Lime
31 32 19 16	31 25 14 13	Geosynthetic Fabric

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SECTION 31 36 13 00 - WIRE MESH GABIONS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of wire mesh gabions. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Description: Gabion units shall consist of compartmented rectangular basket containers filled with stone. The required sizes of the gabion units are Length times Width times Depth. Twisted or welded wire mesh shall be used. Baskets shall be fabricated from galvanized steel wire formed into a nonraveling mesh.

C. Submittals
1. Samples: Stone fill material submitted for approval prior to delivery.

1.2 PRODUCTS

A. Steel Twisted Wire Mesh Gabions: Gabion basket units shall be of nonraveling construction and fabricated from a double twisted hexagonal wire mesh. The size of mesh openings shall be approximately 3-1/4 in. by 4-1/2 in. (80 by 115 mm). The gabion mesh wires shall be wrapped around the selvage wire no less than 1 1/2 times and shall interconnect with adjacent mesh wires. All steel wire used shall be galvanized prior to fabrication into mesh. All gabion diaphragm and frame wire shall equal or exceed ASTM A 641, and possess soft tensile strength of 60,000 psi (415 Mpa) with a tolerance of minus 2,000 psi (14 Mpa). The galvanized wire shall have a Finish 5, Class 3, zinc coating, as indicated in ASTM A 641. The weight of coating shall be determined by ASTM A 90. The grade of zinc used for coating shall be High Grade or Special High Grade as prescribed in ASTM B 6, Table 1. The uniformity of coating shall equal or exceed four 1-minute dips by the Preece Test, as determined by ASTM A 239.

B. Steel Welded Wire Mesh Gabions: Gabion basket units shall be of nonraveling construction and fabricated from a welded square wire mesh. The size of mesh openings shall be approximately 3 in. by 3 in. (75 by 75 mm). The welded joints of the wire mesh shall conform to ASTM A 1064 except that the weld shears shall be at least 600 lbs (2700 N). All gabion diaphragm and frame wire shall equal or exceed ASTM A 641, and possess soft tensile strength of 60,000 psi (415 Mpa) with a tolerance of minus 2,000 psi (14 Mpa). The galvanized wire shall have a Finish 5 Class 3 zinc coating, indicated in ASTM A 641. The weight of coating shall be determined by ASTM A 90. The grade of zinc used for coating shall be High Grade or Special High Grade as prescribed in ASTM B 6, Table 1. The uniformity of coating shall equal or exceed four 1-minute dips by the Preece Test, as determined by ASTM A 239.

C. Mesh wire shall be minimum 0.120-in. (3.05 mm) diameter after coating with 0.85 oz/sq ft (240 g/sq m) zinc coating.

D. Selvage wire shall be minimum 0.150-in. (3.80 mm) diameter after coating with 0.85 oz/sq ft (240 g/sq m) zinc coating.

E. Wire used for lacing or as internal connecting wire within basket cells shall be minimum 0.087-in. (2.21 mm) diameter after coating with 0.70 oz/sq ft (220 g/sq m) zinc coating and may have soft tensile strength designation.

F. Stone Fill

1. Quality: Stone shall be durable and of suitable quality to ensure permanence in the structure and climate in which it is to be used. It shall be free of cracks, seams, and other defects that would tend to increase unduly its deterioration from natural causes or reduce its size to that which could not be retained in the gabion baskets. The inclusion of more than 5% by weight of dirt, sand, clay, and rock fines will not be permitted. The sources from which the Contractor proposes to obtain the material shall be selected well in advance of the time when the material will be required in the work. Suitable samples of stone fill material shall be collected in the presence of the Owner's representative and submitted to the Owner for approval prior to delivery of any such material to the site of the work. Unless otherwise specified, all test samples shall be obtained by the Contractor and delivered at its expense to the Owner. Suitable tests and/or service records will be used to determine the acceptability of the stone. In the event suitable test reports and service records are not available, the material shall be subjected to such tests as are necessary to determine its acceptability for use in the work. Tests to which the material may be subjected include petrographic analysis, specific gravity, absorption, wetting and drying, freezing and thawing, and such other tests as may be considered necessary to demonstrate to the satisfaction of the Owner that the materials are acceptable for use in the work.
2. Gradation: Stone fill used in the gabions shall be a well-graded mixture with sizes ranging between 4 in. and 8 in. (100 and 200 mm), based on US Standard square mesh sieves. No stone shall have a minimum dimension less than 4 in. (100 mm) and a maximum dimension greater than 12 in. (300 mm) in any direction. The ratio of the maximum dimension to the minimum dimension shall not be greater than two. If the height of the gabion basket is 12 in. (300 mm) or less, stone shall have no dimensions greater than 8 in. (200 mm) in any direction.
3. Filter Material: The material shall be composed of tough durable particles, reasonably free from thin, flat, and elongated pieces, and contain no organic matter or soft friable particles in quantities considered objectionable by the Owner. Filter material shall consist of sand and gravel or crushed stone, well graded between the prescribed limits listed below, and conform to the requirements of paragraph STONE FILL, subparagraph QUALITY as to quality.

1.3 EXECUTION:

A. Foundation Preparation: No foundation preparation work shall take place on frozen or snow-covered ground. After excavation or stripping to the extent indicated on the drawings or as directed by the Owner, all remaining loose or otherwise unsuitable materials shall be removed. All depressions shall be carefully backfilled to grade. If pervious materials are encountered in the foundation depressions, the areas shall be backfilled with free-draining materials. Otherwise, the depressions shall be backfilled with suitable materials from adjacent required excavation, or other approved source, and compacted to a density at least equal to that of the adjacent foundation. Any buried debris protruding from the foundation that will impede the proper installation and final appearance of the gabion layer shall also be removed, and the voids carefully backfilled and compacted as specified above. Immediately prior to placing the material, the prepared foundation surface shall be inspected by the Owner, and no material shall be placed thereon until that area has been approved.

B. Filter Placement: Filter material shall be spread uniformly on the prepared foundation surface in a manner satisfactory to the Owner, and to the slopes, lines, and grades as indicated on the drawings or as directed. Placing of filter material by methods which will tend to segregate particle sizes will not be permitted. Any damage to the foundation surface during filter placement shall be repaired before proceeding with the work. Compaction of the filter materials will not be required, but it shall be finished to present a reasonably even surface free from mounds or windrows.

C. Fabrication: Gabions shall be fabricated in such a manner that the sides, ends, lid, and diaphragms can be assembled at the construction site into rectangular baskets of the sizes specified and shown on the drawings. Gabions shall be of single unit construction, i.e., the base, lid, ends, and sides shall be either woven into a single unit, or one edge of these members connected to the base section of the gabion in such a manner that the minimum strengths of the wire mesh and connections as stated in paragraph

MATERIALS are met. Where the length of the gabion exceeds one and one-half its horizontal width, the gabion shall be equally divided by diaphragms of the same mesh and gage as the body of the gabions, into cells whose length does not exceed the horizontal width. The gabion shall be furnished with the necessary diaphragms secured in proper position on the base in such a manner that no additional tying at this juncture will be necessary. For twisted wire gabions, all perimeter edges of the mesh forming the gabion shall be securely selvaged. In addition, the selvaged edges shall be so wrapped and reinforced with the mesh ends that the selvage wire will not be deformed locally about the lacing wire or wire fasteners when baskets are filled or during lid closing. Lacing wire, connecting wire, and/or wire fasteners shall be supplied in sufficient quantity for securely fastening all diaphragms and edges of the gabion.

D. Assembly And Installation: For gabion units in excess of 4 ft. (1.3 m) in thickness, and placed in horizontal or near horizontal position to resist high velocity flow, or as part of a stilling basin feature, a minimum of two uniformly spaced vertical connecting wires per cell linking the foundation mesh to basket lid mesh should be specified. Empty gabion units shall be assembled individually and placed on the approved surface with the sides, ends, and diaphragms erected in such a manner to ensure the correct position of all creases and that the tops of all sides are level. Filling of gabion units in one place and then transporting them to their final position in the work will not be permitted. The front row of gabion units shall be placed first and successively constructed toward the top of the slope or the back of the structure. All gabion units shall be properly staggered horizontally and vertically. Finished gabion structure shall have no gaps along the perimeter of the contact surfaces between adjoining gabion basket units. All adjoining empty gabion units shall be connected by lacing wire/or wire fasteners along the perimeter of their contact surfaces in order to obtain a monolithic structure. Lacing of adjoining basket units shall be accomplished by continuous stitching with alternating single and double loops at intervals of not more than 5 in. (125 mm), and a half hitch shall be included at every double loop. All lacing wire terminals shall be securely fastened. Wire fasteners may be used in lieu of lacing wire for forming individual baskets and joining empty baskets together prior to stone filling. All joining shall be made through selvage-to-selvage or selvage-to-edge wire connection; mesh-to-mesh or selvage-to-mesh wire connection is prohibited except in the case where baskets are offset or stacked and selvage-to-mesh or mesh-to-mesh wire connection would be necessary. Wire fasteners shall not be used to tie or join stone-filled baskets, unless approved by the Owner. As a minimum, a fastener shall be installed at each mesh opening at the location where mesh wire meets selvage or edge wire. The initial line of basket units shall be placed on the prepared filter layer surface and partially filled to provide anchorage against deformation and displacement during filling operations. After adjoining empty basket units are set to line and grade and common sides with adjacent units thoroughly laced or fastened, they shall be placed in tension and stretched to remove any kinks from the mesh and to a uniform alignment. The stretching of empty basket units shall be accomplished in such a manner as to prevent any possible unraveling. Stone filling operations shall carefully proceed with placement by hand or machine so as not to damage galvanized wire coating, to assure a minimum of voids between the stones, and the maintenance of alignment throughout the filling process. Undue deformation and bulging of the mesh shall be corrected prior to further stone filling. To avoid localized deformation, the basket units in any row are to be filled in stages consisting of maximum 12-in. (300 mm) courses, and at no time shall any cell be filled to a depth exceeding 1 ft. (300 mm) more than the adjoining cell. The maximum height from which the stone may be dropped into the basket units shall be 36 in. (1 m). For gabion units in excess of 2 ft. (0.67 m) in height, two uniformly spaced internal connecting wires shall be placed between each stone layer in all front and side gabion units, connecting the back and the front faces of the compartments. Connecting wires or alternatively the preformed stiffeners shall be looped around two twisted wire mesh openings or a welded wire joint at each basket face and the wire terminals shall be securely twisted to prevent their loosening. For twisted wire gabions, the internal connecting wires or preformed stiffeners are installed. For welded wire gabion units, preformed stiffeners are installed across the corners of gabion panels. Along all exposed faces, the outer layer of stone shall be carefully placed and arranged by hand to ensure a neat and compact appearance. The last layer of stone shall be uniformly overfilled 1 to 2 in. (25 to 50 mm) to compensate for the future settlement in rock but still allow for the proper closing of the lid and to provide an even surface that is uniform in appearance. Final adjustments for compaction and surface tolerance shall be done by hand. Lids shall be stretched tight over the stone fill using only an approved lid closing tool, until the lid meets the perimeter edges of

the front and end panels. Using crowbars or other single point leverage bars for lid closing shall be prohibited. The lid shall then be tightly tied with lacing wire, or with wire fasteners if approved by the Owner, along all edges, ends, and internal cell diaphragms by continuous stitching with alternating single and double loops at intervals of not more than 5 in. (125 mm), and a half hitch shall be included at every double loop. Special attention shall be given to see that all projections or wire ends are turned into the baskets. The Contractor shall have the option of providing gabion baskets with separate roll-out lids for the slope baskets. Roll-out lids shall be fabricated of the same material as the basket units and shall be furnished in widths as required for the contract work. as directed by the Owner, or where a complete gabion unit cannot be installed because of space limitations, the basket unit shall be cut, folded, and wired together to suit existing site conditions. The mesh must be cleanly cut and the surplus mesh cut out completely, or folded back and neatly wired to an adjacent gabion face. The assembling, installation, filling, lid closing, and lacing of the reshaped gabion units shall be carried out as specified above.

END OF SECTION 31 36 13 00

SECTION 31 37 13 00 - RIPRAP

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of riprap. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Demolition and removal of materials shall be as required to support the work.

1.2 PRODUCTS

A. Riprap: Stone used for dumped riprap shall be hard, durable, angular in shape, resistant to weathering and to water action, and free from overburden, spoil, shale, and organic material. Neither width nor thickness of a single stone should be less than one third its length. Rounded stone, boulders, shale, and stone with shale seams will not be acceptable. The minimum density of the riprap material shall be 162 pounds per cubic foot. Each load of riprap shall be reasonably well graded. Sand and rock dust exceeding 5 percent by weight of each load shall not be permitted.

B. Riprap Bedding: The riprap bedding blanket shall consist of well graded gravel, crushed rock, sand, or a combination thereof with a maximum size of 6 inches. All material comprising the riprap bedding blanket shall be composed of tough, durable particles, reasonably free from thin, flat, and elongated pieces, and shall contain no organic matter nor soft, friable particles in excess quantities.

1.3 EXECUTION

A. Preparation: Prepare earth slopes by grading and compacting.

B. Installation:
1. Riprap Bedding Blanket Layers shall be placed on the prepared slope or area to develop the full thickness. Each layer shall be placed in one operation, using methods that will not cause segregation of particle sizes within the bedding. The surface of the finished layer should be reasonably even and free from mounds or windows.
2. Stone for Riprap shall be placed on the prepared slope or area in a manner that will product a reasonably well-graded mass of stone with the minimum practicable percentage of voids. Riprap shall be placed to its full course in one operation and in such a manner as to avoid displacing the underlying material. The larger stones shall be well distributed and the entire mass of stone shall be well-graded. The result shall be a compact, uniform riprap layer.

END OF SECTION 31 37 13 00

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Task	Specification	Specification Description
31 37 13 00	01 22 16 00	No Specification Required
31 37 13 00	31 32 19 16	Sewage Treatment Lagoons
31 41 16 13	31 23 16 13	Excavation Support And Protection
31 45 13 00	31 32 13 19	Soil Stabilization-Vibroflotation

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SECTION 31 62 13 23 - PRESTRESSED CONCRETE PILES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for relief wells. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Shop Drawings: Submit shop drawings.
2. Statements
a. Before installation, all well screen shall be approved.
b. The filter pack material and its gradation shall be approved before it is placed.
c. Submit the cement grout mixture proportion to be used in plugging abandoned wells.
3. Reports: Submit sampling and testing reports for each relief well, logs of the borings, well screen and riser pipe, backfill material, and pump tests. Register each well with the state as required by the state in which the well is installed.

C. Regulatory Requirements: The state statutory and regulatory requirements form a part of this specification.

1.2 PRODUCTS

A. Well Screen: The Contractor may, at its option, furnish and install well screen of any of the alternate types specified. The clear inside diameter of the screen shall be as directed by the Owner. Screen openings shall be uniform in size and pattern, and shall be spaced approximately equally around the circumference of the pipe.
1. PVC Pipe Screen: Pipe, fittings, and screen shall be of the size and types specified. Pipe, fittings, and screen shall conform to ASTM D 1784, ASTM D 1785, ASTM D 2466, or ASTM D 2467. All joints in the PVC pipe shall include couplings and shall be glued with a solvent cement conforming to ASTM D 2564. The PVC pipe strength properties shall be equivalent to PVC 1120 Schedule 40 **OR** 80, **as directed**, unthreaded plastic pipe.
a. Couplings: Couplings shall be bonded socket **OR** threaded, **OR** certilock, **as directed**, type. Fittings shall be produced of the same material and equal quality as specified for plastic pipe screen. Socket type fitting connections of pipe sections shall be bonded with solvent cement. The determination of the proportions and preparation of adhesives, the method of application, and the procedure used for making and curing the connections shall be the responsibility of the Contractor. The system for making joints at the relief well site shall provide a curing period adequate to develop the ultimate strength of the solvent cement. Self-tapping screws or other devices for holding pipe in the couplings during the setting period may be utilized as long as the screws do not penetrate the inside of the pipe. In no case shall a newly-made joint in the casing be stressed, lowered into the relief well, or be submerged in water prior to complete curing of the solvent cement adhesive.
b. Perforations: The PVC well screen shall be mill slot **OR** continuous wire wrapped rod base **OR** continuous wire wrapped rod base on perforated pipe **OR** continuous wire wrapped on perforated pipe screen **OR** similar to that manufactured by Johnson Well Equipment, Inc., Pensacola, FL, telephone (904) 453-3131, **as directed**. All well screen shall have smooth, sharp-edged openings free of burns, chipped edges, or broken areas on the interior and exterior surfaces of the pipe. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe and shall be oriented with the length of the slot parallel to, normal to, or diagonal with the axis of the pipe.

2. Fiberglass Pipe Screen: Fiberglass pipe screen and fittings shall be manufactured from thermosetting epoxy resins and glass fiber by either a centrifugal casting process or by a filament winding process. Glass fiber used shall be continuous filament, electrical glass with a finish compatible with epoxy resins. Each glass fiber or filament shall be thoroughly impregnated with epoxy resin. Fiberglass pipe wall thickness, strength and durability requirements shall be equivalent to the Fiberglass/Epoxy pipe produced by Fiberglass Resources Corporation of Farmingdale, New York or Burgess Well Company, Inc., Minden, Nebraska, telephone (308) 832-1642. All fiberglass pipe and fittings shall be round and straight, of uniform quality and workmanship, and free from all defects including indentation, delamination, bends, cracks, blisters, porosity, dry spots, resin segregation and resin-starved areas. The inside of the pipe and fittings shall be smooth and uniform. The impregnation of the glass fiber with resin shall be such that when the pipe is cut or slotted, no fraying or looseness of glass fiber occurs.
   a. Couplings: Couplings for fiberglass pipe sections shall be socket threaded or mechanical key-type couplings. The couplings shall be manufactured of the same materials used for the fiberglass pipe specified herein and may be either cast integrally with the pipe sections or as separate components for attachment to the pipe in the manufacturers plant. Key-type couplings shall consist of male and female halves designed for joining and locking together by means of a key strip inserted in grooves in the coupling halves. The minimum wall thickness remaining at any grooved section shall not be less than the minimum thickness specified for pipe. Key strips and locking strips shall be of fiberglass, plastic or other non-corrosive material capable of withstanding shearing and bearing stresses equivalent to the design load for the coupling. Socket type fitting connections of the pipe sections shall be bonded with epoxy adhesive. The epoxy materials and bonding agents shall be as recommended by the pipe manufacturer. Self-tapping screws or other devices for holding adhesive-joined pipe in the couplings during the curing period may be utilized. In no case shall a newly-made joint in the casing pipe be lowered into the relief well, or be submerged in water prior to complete curing of the adhesive.
   b. Perforations: All fiberglass well screen shall be mill slot **OR** continuous wire wrapped rod base, **as directed**. All relief well screen shall have smooth, sharp-edged openings free of burrs, chipped edges, or broken areas on the interior and exterior surfaces of the pipe. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe and shall be oriented with the length of the slot parallel to, normal to, or diagonal with the axis of the pipe.
3. Steel Pipe Screen: Steel well screen shall consist of perforated or slotted sections of steel pipe conforming to the requirements of ASTM A 53.
   a. Couplings: Couplings for steel pipe screen shall be welded joints or threaded couplings. Welding shall be performed in accordance with requirements in ASME B31.9. Couplings shall meet the material requirements specified for steel pipe screen, except perforations shall be omitted. All threaded pipe and fittings shall be threaded in accordance with ASME B1.20.1. All threaded pipe sections may be field connected. Couplings shall be given the same protection against corrosion as specified for the well screen pipe. Protective coatings damaged while making couplings shall have the areas recoated.
   b. Perforations: All steel pipe to be used as relief well screen shall be provided with perforations which shall consist of either machine-cut slots; drilled or punched openings. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe and shall be oriented with the length of the slot parallel to, normal to, or diagonal with the axis of the pipe. The pattern of the openings shall be uniformly spaced around the periphery of the pipe.
4. Stainless Steel Well Screen: The perforated well screen and fittings shall be fabricated entirely from stainless steel conforming to ASTM A 312/A 312M, Type 304, 304-L, 316 or 316-L. The well screen shall be of stainless steel with a keystone wire-wrapped continuous slot strainer equivalent to that manufactured by Howard Smith Screen Company, Houston, TX, telephone (713) 869-5771 or Johnson Screens, St. Paul, MN 55164, telephone (612) 636-3900.
   a. Couplings: Couplings for the stainless steel well screen shall consist of the same material as the well screen and shall be threaded, flanged, and/or fitted with a welding ring. The

couplings shall conform in design to the couplings recommended by the manufacturer of the well screen.

b. Tailpipe for Well Screen: The tailpipe for each well screen shall be made of the same material and at least the same minimum thickness as the riser pipe and shall include a bottom plug.

B. Riser Pipe: The relief well riser pipe material and method of manufacture shall conform to the requirements specified in paragraph WELL SCREEN, except that the screen perforations or opening shall be omitted. The relief well riser pipe diameter and discharge details shall be as directed. Couplings to the well screen and between riser pipe sections shall be as specified in paragraph COUPLING.

C. Filter Pack: Material for the filter pack around the riser pipes and screens shall be a washed grave, **OR** washed sand **OR** dry processed sand, **as directed**, composed of hard, tough, and durable particles free from adherent coating. The filter pack shall not be crushed stone. The filter pack material shall contain no detrimental quantities of organic matter nor soft, friable, thin, or elongated particles in accordance with the quality requirements in ASTM C 33, Table 1 and Table 3, Class 5S, and in ASTM E 11, Table 1.

D. Outlet For Relief Well: Check Valve.

1. The check valve shall be a one piece reinforced all rubber (neoprene) check valve with an integral elastomer flange similar and equal to the Red Valve Series 35, manufactured by Red Valve Company, Inc., 700 North Bell Ave., Pittsburgh, PA 15106, telephone (412) 279-0044. The backup ring for the check valve shall be stainless steel. Stainless steel bolts, washers, and nuts shall be used to fasten the valves onto the flanged end of the pipes. The check valve shall be installed with the flared end duck bill in a vertical position.
   OR
   Fabricate check valves of brass **OR** stainless steel **OR** aluminum, **as directed**, plate, threaded fasteners and rods. Fabricate sealing disc of silicone sponge rubber free of porous areas, foreign materials, and visible defects.
2. Workmanship and metalwork fabrication of check valves shall be as directed. Install check valves accurately vertically and adjust to the required elevation.

E. Concrete: Concrete shall conform to the requirements specified in Division 03 Section "Cast-in-place Concrete".

1.3 EXECUTION

A. Drilling: Wells may be drilled by the reverse rotary circulation method or other method approved, which will ensure proper placement of the well screen, riser pipe, and filter pack. Methods which involve radical displacement of the formation, or which may reduce the yield of the well, will not be permitted. Excavated material shall be disposed of as directed.

1. Reverse Circulation Method: If the reverse circulation method is used for drilling wells, all of the drilling fluid shall be removed from the filter pack and the natural pervious formation. If in the opinion of the Owner the walls of the hole above the top of the filter pack require support during development operations, a temporary casing similar to that specified in paragraph TEMPORARY CASING shall be placed so as to extend from the ground surface to at least 3 ft (1 m) below the top of the filter pack. The diameter of the hole shall be such as will permit the placement of the minimum thickness of filter pack as specified in paragraph FILTER PACK PLACEMENT. The drilling fluid shall be a suspension of fine grained soil or shall be a commercial product of a recognized manufacturer, shall be approved by the Owner, and shall have the characteristic of being readily removable from the filter pack and the walls of the formation by development as specified in paragraph DEVELOPMENT. The use of bentonite will not be permitted.
2. Temporary Casing: Temporary well casing of either iron or steel of sufficient length to case to the bottom of all borings shall be available at the construction site. the Owner will direct the use of a temporary casing to the bottom of the boring during drilling and placement of screen, riser, and

filter pack when it believes it is necessary to provide adequate support to the sides of the hole. When the walls of the boring will require support only during development operations a temporary casing will be required to extend only to a depth 3 ft (3 m) below the top of the filter pack. The temporary casing, shall have sufficient thickness to retain its shape and maintain a true section throughout its depth, and may be in sections of any convenient length. The temporary casing shall be such as to permit its removal without disturbing the filter pack, riser, or well screen. The setting of temporary casing shall be such that no cavity will be created outside of it at any point along its length. In the event the temporary casing should become unduly distorted or bent it shall be discarded and a new casing shall be used during installation of any additional relief wells.

B. Installation Of Riser Pipe And Screen

1. Assembly: All riser pipe and screen shall be in good condition before installation and all couplings and other accessory parts shall be securely fastened in place. The successive lengths of pipe shall be arranged to provide accurate placement of the screen sections in the bore hole. The riser-pipe shall be provided with an approved cap and a flanged top section, the top of which shall be set at the elevation directed. Centralizers shall be attached to the assembled riser pipe and screen in such numbers and of a type that they will satisfactorily center the riser pipe and screen in the well and will hold it securely in position while the filter pack material is being placed.
2. Joints: Sections of relief well pipe shall be joined together as specified in paragraph COUPLINGS. Joints shall be designed and constructed to have the strength of the pipe and where possible a strength capable to support the weight of the relief well stem as it is lowered into the hole. When not practicable to construct joints that will support the weight of the relief well stem, the stem shall be supported at the lower end by any approved means that will assure that the joints do not open while being lowered into place in the well.
3. Installation: The assembled riser pipe and screen shall be placed in the bore hole in such manner as to avoid jarring impacts and to ensure that the assembly is centered and not damaged or disconnected. The screen shall be suspended in the hole and not resting on the bottom of the hole. After the screen and riser pipe have been placed, a filter pack shall be constructed around the screen section as specified in paragraph FILTER PACK PLACEMENT and the well developed as specified in paragraph DEVELOPMENT. The top of the riser pipe shall be held at the designated elevation during placement of the filter pack.
4. Check for Plumbness and Alignment: The well shall be constructed and all casing set round, plumb, and true. The Contractor shall perform the following tests after the installation of the well but prior to backfilling, and before its acceptance. Additional tests may be made during the performance of the work at the option of the Contractor. Should the Contractor fail to correct, at no additional cost to the Owner, any faulty alignment or plumbness disclosed as a result of these tests, the Owner may refuse to accept the well. the Owner may waive the requirements for plumbness if in its judgement the Contractor has exercised all possible care in constructing the well and the defect is due to circumstances beyond its control or if the utility of the completed well is not materially affected or if the cost of necessary remedial measures will be excessive. In no event will the provisions with respect to alignment be waived.
   a. Plumbness: Plumbness shall be tested by use of a plumb line. The plummet shall be suspended from a small diameter wire rope and its point of suspension shall be in the exact center of the plummet. The plummet shall be sufficiently heavy to stretch the wire rope taut. The wire rope shall pass over a guide sheave which shall be positioned above the top of the well and adjusted horizontally so that the plummet hangs in the center of the well. Displacement of the wire rope during the plumbness check shall be measured by means of a transparent plastic sheet on which a number of concentric circles shall be scribed or drawn, and which is centered on the top of the well. The exact center of these circles shall be marked, and then a slot, slightly larger than the plumb line and extending from this center to the edge, shall be cut in the plastic sheet. As the plummet is lowered, any out-of-plumb condition of the well will be indicated by the wire rope tending to drift away from the center, and the plastic sheet shall be rotated until the slot is oriented in the direction of this drift, while at all times maintaining the center of the concentric circles coincident with the center of the well. Measurement of the amount of drift shall be made

along the edge of the slot for each increment by which the plummet is lowered into the well. Drift at any depth shall be determined by multiplying the measured plumb line displacement by the total length of the plumb line and dividing the result by the fixed distance between the guide sheave and the top of the well. If desired, alignment may be calculated from the plumbness data in lieu of the alignment check described in paragraph ALIGNMENT. Should the well vary from the vertical in excess of allowable, the plumbness of the well shall be corrected by the Contractor at no additional cost to the Owner.

b. Alignment: Alignment shall be tested by lowering into the well a section of cylinder or a dummy of the same length. The outside diameter of cylinder shall be smaller than the inside diameter of the well. Should the cylinder fail to move freely throughout the length of the well, the alignment of the well shall be corrected by the Contractor at no additional expense to the Owner.

C. Filter Pack Placement: After the well screen and riser pipe have been installed, the filter pack material shall be placed by tremie, when using a well graded material, in an approved manner such that segregation will not occur. When using a uniform graded filter material, the material may be poured around the well screen at a rate that will prevent bridging of the material. The material shall be placed around all sides of the screen to assure that the screen is not pushed against the side of the bore hole causing the screen to come in contact with foundation material or prevent the proper thickness of filter from being placed uniformly around the screen. The filter pack shall be placed at a constant rate from the start of placement until it has reached the elevation directed. If a tremie is required, a double string of tremie pipe shall be used. The pipes shall be placed on opposite sides of the screen and/or casing, that is, 180 degrees apart, and shall be guided in such a manner that they will remain in this position throughout the placing process. The tremie pipes shall be set in place, filled completely with filter pack prior to being lifted off the bottom of the hole. The filter pack in the tremie pipe shall be kept above the water surface in the well throughout the placing process. In no case shall the gradation of the filter pack fall outside of the range specified in paragraph FILTER PACK.

D. Development

1. General: Following placement of filter pack materials, the Contractor shall develop the relief well by jetting, surging, intermittent pumping, or other approved methods as may be necessary to give the maximum yield of water. At the time of development of any relief well, the well shall be free of drawdown or surcharge effects due to pump testing, developing or drilling at another location. The Contractor shall be responsible for maintaining at the relief well the needed access and work area and clearance in the relief well necessary to accomplish development. The Contractor shall furnish, install, or construct the necessary discharge line and troughs to conduct and dispose of the discharge a sufficient distance from the work areas to prevent damage. Development shall be conducted to achieve a stable well of maximum efficiency and shall be continued until a satisfactory sand test, as specified in paragraph SAND TEST, is obtained. As development proceeds, filter pack material shall be added to the annular space around the screen to maintain the top elevation of the filter pack to the specified elevation. The Contractor shall provide an open tube or other approved means for accurately determining the water level in the well under all conditions. If at any time during the development process it becomes apparent in the opinion of the Owner that the well may be damaged, development operations shall be immediately terminated. the Owner may require a change in method if the method selected does not accomplish the desired results. the Owner may order that wells which continue to produce excessive amounts of fines after development for 6 hours be abandoned, plugged, and backfilled, and may require the Contractor to construct new wells nearby. All materials pulled into the well by the development process shall be removed prior to performing the pumping test.

a. Jetting: Jetting should be performed using either a single or double ring jet. The jetting tool shall be constructed of high-strength material and conservatively designed and proportioned so that it will withstand high pressures. The jetting tool shall have two hydraulically balanced nozzles spaced 180 degrees **OR** four diameter holes spaced 90 degrees, **as directed**, apart and which shall exert the jetting force horizontally through the screen slots. The rings shall be constructed such that the tips of the jets shall be within 1/2 in. (13 mm) from the inner surface of the well screen. The pump used in conjunction with

the jetting tool shall be capable of providing a minimum jetting fluid exit velocity of 150 feet per second (45 meters per second). Prior to commencing jetting, and following each jetting cycle, all sand and/or other materials shall be removed from inside the screen. All wells shall be pumped during the jetting cycle to remove incoming sand and other material. Such pumping shall be at a rate not less than 115 percent of the rate at which fluid is introduced through the jetting tool. This will allow a flow of material into the well as it is being developed. Water used for development shall be free of sand. the Owner may require other means of developing the well such as intermittent pumping method, variation of the intermittent pumping method, or surge block if it appears that the development of the well is not producing the desired results.

b. Intermittent Pumping: Intermittent pumping shall be performed by pumping the well at a capacity sufficient to produce a rapid drawdown, stopping the pump (backflow through pump will not be permitted) to permit the water surface to rise to its former elevation, and repeating this procedure. Cycle time for this procedure will vary as directed but will not be more than 3 cycles per minute. A deep well turbine pump, or electric submersible pump with check valve, shall be used with any attachment necessary to accomplish rapid starting and stopping for intermittent pumping. The intake shall be set below the maximum expected drawdown in the well. Prior to commencing intermittent pumping, and periodically during development by this method, all sand and/or other materials shall be removed from inside the screen. The amount of drawdown may be decreased if, in the opinion of the Owner, the efficiency of the well might otherwise be impaired.

c. Surging: Surging of the well shall require use of a circular block which is smaller in diameter than the inside diameter of the relief well and is constructed of a material which will not damage the screen if the block comes in contact with the screen, and a bailer or pump to remove materials drawn into the well. The surging shall be continued for a period of approximately one hour or until little or no additional material from the foundation or filter pack can be pulled through the screen. The surge block shall be moved by a steady motion up and down the full length of the well screen. Prior to commencing surging, and periodically during development by this method, all sand and/or other materials shall be removed from inside the screen. All materials pulled into the well by the surging process shall be removed by the Contractor.

E. Backfilling: After the well has been developed, additional filter pack shall be added if necessary to meet the requirements of paragraph FILTER PACK PLACEMENT. Then the annular space above the filter pack, shall be backfilled by first placing a layer of concrete sand on the filter pack and then filling the remainder of the space up to the finished ground surface **OR** well pit, **as directed**, with grout or concrete. The concrete backfill shall be placed to a depth at least equal to the existing impervious blanket. For PVC riser pipe, after the well has been developed, additional filter pack shall be added if necessary for it to meet the requirements of paragraph FILTER PACK PLACEMENT. Then the remaining annular space above the filter pack shall be backfilled by first placing a layer of concrete sand on the filter pack and then filling the remainder of the space up to the finished ground surface **OR** well pit, **as directed**, with bentonite. The temporary casing, if used, shall be withdrawn in increments as the backfill is placed. The Contractor shall fill with impervious material to original grade all pits such as those incidental to the reverse rotary circulation method of drilling.

F. Plugging Of Abandoned Wells: The Contractor has the option of attempting to remove the well screen. If the well screen can be removed, the Contractor will grout the bore hole starting from the bottom of the hole. The grouting shall start at the elevation of the bottom of the tailpipe of the well. If the well screen can not be removed or breaks off during the removal attempt, the Contractor shall still be responsible for grouting the well from the bottom of the tailpipe to within 3 ft (1 m) of ground surface. Either of the above abandonment procedures may require the Contractor to redrill the hole so that the bore hole can be grouted. The well shall be grouted from the bottom of the tailpipe. After the grout has setup the riser pipe shall be cutoff. Then the hole shall be backfilled. The cement grout mixture proportion to be used shall be submitted for approval.

G. Tests

1. Pump Test: Upon completion but before acceptance, each well shall be subjected to a pump test of which a sand test will form a part. The Contractor shall provide a deep well turbine pump, capable of producing the specified drawdowns over periods of time sufficient to satisfactorily perform the pump test specified herein. The intake shall be set below the maximum expected drawdown in the well. The amount of sand shall be measured after each test. The pump shall be complete with either gasoline, diesel, or electric motor of adequate size. In case an electric motor is used, the Contractor shall provide, without additional cost to the Owner, the electric power and the necessary wiring. The Contractor shall provide an open tube or other approved means for accurately determining the water level in the well. The Contractor shall furnish and install an orifice meter of approved design or other approved equipment for the purpose of measuring the discharge from the well during the pumping test. The Contractor shall furnish, install, or construct the necessary pipe discharge line, troughs, or ditches necessary to dispose of the pumping test discharge a sufficient distance from the work area to prevent damage. The tests will be conducted under the direction of the Owner and may be made as soon as each well is completed. Test data will be recorded by the Owner. The Contractor shall test each well by pumping continuously for a minimum of 6 hours. Prior to starting the pump test all material shall be removed from the bottom of the well. If the test is interrupted, other than by order of the Owner, prior to the completion of the specified period of continuous operation, the test shall be re-run. In addition to the required pumping test, the Owner may direct the Contractor to perform additional pump tests. Such additional testing shall conform in general to the requirements specified herein except that the duration of the tests and the approximate draw-down will be determined by the Owner. In the event that sand or other material collects in the well as a result of the pump test, accurate measurements shall be taken as to the quantity of material in the well and all such material shall be removed by the Contractor. Upon completion of the pump test, the Contractor shall remove all equipment, discharge lines, electrical lines, lumber, and debris, and shall backfill any excavated areas with impervious material.
2. Sand Test: As part of each Pump Test or at the end of each intermittent pumping a determination of the amount of sand (filter pack and/or foundation material) a well is producing shall be performed. Prior to starting the sand test all material shall be removed from the bottom of the tailpipe. After the pump is at the desired pumping rate the flow from the discharge shall be diverted into a container that will collect all the sand being carried by the water **OR** through a Rossum Sand Tester, **as directed**. Upon completion of the test the amount of sand in the tailpipe shall be determined to verify that no material is being deposited in the bottom of the well.
3. Filter Pack Sampling and Testing: The Contractor shall verify that all materials conform to the specifications before delivery to the project. The particle size distribution of the filter pack shall be sampled and tested by the Contractor in accordance with ASTM C 136 and ASTM D 75. Within 48 hours before being placed in the relief well to be back-filled, the filter pack shall be sampled from the material stockpiled at the project site. There shall be at least one particle size distribution test on the filter pack for each well. A pump test shall be performed in accordance with technical provisions herein specified.
4. Reports: Reports shall include, for each relief well, logs of the boring, elevations of the well screen, top of riser pipe, bottom of the tailpipe, filter pack gradation, quantity of filter pack added during development, pump test, sand test, and report of backfilling. The log of backfill material shall include the filter pack particle size distribution test data, and notes concerning installation and development of the relief well. The pump test log shall include the duration of the test and the draw-down response data with time in the pumped well, in adjacent wells, and in nearby piezometers. The relief well log and the pump test log shall be submitted to the Owner. The Contractor shall also submit a report of the well installation to the appropriate public agency and in the form required by state statutory and/or regulatory requirements specified in paragraph REGULATORY REQUIREMENTS.

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SECTION 31 62 16 16 - STEEL H PILES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for steel H piles. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes steel H piles.

C. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For steel piles. Show fabrication and installation details for piles, including details of driving points, splices, and pile caps.
   a. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld.
   b. Include arrangement of static pile reaction frame, test and anchor piles, equipment, and instrumentation. Submit structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Welding certificates.
4. Mill Test Reports: For steel H piles, steel castings, and steel plate, signed by manufacturer.
5. Pile-Driving Equipment Data: Include type, make, and rated energy range; weight of striking part of hammer; weight of drive cap; and, type, size, and properties of hammer cushion.
6. Static Pile Test Reports: Submit within three days of completing each test.
7. Pile-Driving Records: Submit within three days of driving each pile.
8. Field quality-control reports.
9. Preconstruction Photographs: Photographs or video of existing conditions of adjacent construction. Submit before the Work begins.

D. Quality Assurance
1. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.
2. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
3. Preinstallation Conference: Conduct conference at Project site.

E. Delivery, Storage, And Handling
1. Deliver piles to Project site in such quantities and at such times to ensure continuity of installation. Handle and store piles at Project site to prevent buckling or physical damage.
   a. Painted Piles: Protect finish and touch up paint damage before driving piles.

F. Project Conditions
1. Protect structures, underground utilities, and other construction from damage caused by pile driving.
2. Preconstruction Photographs: Inventory and record the condition of adjacent structures, underground utilities, and other construction. Provide photographs **OR** video, **as directed**, of conditions that might be misconstrued as damage caused by pile driving.

1.2 PRODUCTS

A. Steel H Piles

1. High-Strength, Low-Alloy, Columbium-Vanadium Structural Steel: ASTM A 572/A 572M, Grade 50 (Grade 345) **OR** Grade 60 (Grade 415), **as directed**.
2. High-Strength, Low-Alloy, Nickel, Copper, Phosphorous Steel H Piles: ASTM A 690/A 690M.
3. High-Strength, Low-Alloy, Structural Steel: ASTM A 588/A 588M.

B. Pile Accessories
1. Driving Points: Manufacturer's standard one-piece driving point, fabricated from steel castings as follows to provide full bearing of web and flange of pile tip:
   a. Carbon-Steel Castings: ASTM A 27/A 27M, Grade 65-35 (Grade 450-240), heat treated **OR** Grade N1, **as directed**.
   b. High-Strength Steel Castings: ASTM A 148/A 148M, Grade 80-40 (Grade 550-275) **OR** Grade 90-60 (Grade 620-415), **as directed**.
2. Splice Unit: Manufacturer's standard splice unit, fabricated from two connected steel plates, of same material as H pile or material of equal strength, shaped to encase web and part of each flange.

C. Paint
1. Paint, **as directed**: SSPC-Paint 16; self-priming, two-component, coal-tar epoxy polyamide, black **OR** red **OR** manufacturer's standard color, **as directed**.

D. Fabrication
1. Fabricate and assemble piles in shop to greatest extent possible.
2. Pile-Length Markings: Mark each pile with horizontal lines at 12-inch (305-mm) intervals; label the distance from pile tip at 60-inch (1.52-m) intervals. Maintain markings on piles until driven.
3. Fabricate full-length piles to eliminate splicing during driving, with ends square.
   OR
   Fabricate full-length piles by splicing lengths of H pile together. Accurately mill meeting ends of piles and bevel for welding. Maintain axial alignment of pile lengths. Maintain structural properties of pile across splice.
4. Splice Units: Notch web of pile, fit splice unit into position, and weld according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.
   OR
   Continuously Welded Splices: Splice piles by continuously welding according to AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.
   a. Splice piles during fabrication or field installation, **as directed**.
5. Fit and weld driving points to tip of pile according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.

E. Shop Painting, **as directed**
1. General: Shop paint steel pile surfaces, except for surfaces to be encased in concrete, as follows:
   a. Extend painting to a depth of 60 inches (1.52 m) below finished grade **OR** low-tide level, **as directed**, to top of exposed pile.
2. Surface Preparation: Clean surfaces to be painted. Remove loose rust and loose mill scale, spatter, slag, and flux deposits. Prepare surfaces according to SSPC-SP 10/NACE No. 2, "Near-White Blast Cleaning."
3. Painting: Immediately after surface preparation, apply coat of paint according to manufacturer's written instructions to provide a dry film thickness of not less than 8 mils (0.2 mm).
   a. Apply second coat to provide a dry film thickness of not less than 8 mils (0.2 mm), resulting in a two-coat paint system thickness of not less than 16 mils (0.4 mm).

b. Apply second and third coats with each coat having a dry film thickness of not less than 8 mils (0.2 mm), resulting in a three-coat paint system thickness of not less than 24 mils (0.6 mm).
c. Mark pile lengths after shop painting.

1.3 EXECUTION

A. Examination
1. Site Conditions: Do not start pile-driving operations until earthwork fills have been completed or excavations have reached an elevation of 6 to 12 inches (152 to 305 mm) above bottom of footing or pile cap.

B. Driving Equipment
1. Pile Hammer: Air-, steam-, hydraulic-, or diesel-powered type capable of consistently delivering adequate peak-force duration and magnitude to develop the ultimate capacity required for type and size of pile driven and character of subsurface material anticipated.
2. Hammer Cushions and Driving Caps: Between hammer and top of pile, provide hammer cushion and steel driving cap as recommended by hammer manufacturer and as required to drive pile without damage.
3. Leads: Use fixed, semifixed, or hanging-type pile-driver leads that will hold full length of pile firmly in position and in axial alignment with hammer.

C. Static Pile Tests, **as directed**
1. General: Static pile tests will be used to verify driving criteria and pile lengths and to confirm allowable load of piles.
a. Furnish test piles 60 inches (1.52 m) longer than production piles.
b. Determination of actual length of piles will be based on results of static pile tests.
2. Pile Tests: Arrange and perform the following pile tests:
a. Axial Compressive Static Load Test: ASTM D 1143.
b. Axial Tension Static Load Test: ASTM D 3689.
c. Lateral Load Test: ASTM D 3966.
3. Equip each test pile with two telltale rods, according to ASTM D 1143, for measuring deformation during load test.
4. Provide pile reaction frame, anchor piles, equipment, and instrumentation with sufficient reaction capacity to perform tests. Notify the Owner at least 48 hours in advance of performing tests. On completion of testing, remove testing structure, anchor piles, equipment, and instrumentation.
a. Allow a minimum of seven days to elapse after driving test piles before starting pile testing.
b. Number of Test Piles: One pile **OR** As indicated, **as directed**.
5. Driving Test Piles: Drive test piles at locations indicated to the minimum penetration or driving resistance indicated. Use test piles identical to those required for Project and drive with appropriate pile-driving equipment operating at rated driving energy to be used in driving permanent piles.
6. Approval Criteria: Allowable load shall be the load acting on the test pile when the lesser of, **as directed**, the following criteria are met, divided by a factor of safety of 2:
a. Net settlement, after deducting rebound, of not more than 0.01 inch/ton (0.25 mm/907 kg) of test load.
b. Total settlement exceeds the pile elastic compression by 0.15 inch (4 mm), plus 1.0 percent of the tip diagonal dimension.
c. A plunging failure or sharp break in the load settlement curve.
7. Test Pile-Driving Records: Prepare driving records for each test pile, compiled and attested to by a qualified professional engineer, **as directed**. Include same data as required for driving records of permanent piles.
8. Test piles that comply with requirements, including location tolerances, may be used on Project.

D. Driving Piles

1. General: Continuously drive piles to elevations or penetration resistance indicated or established by static load testing of piles, **as directed**. Establish and maintain axial alignment of leads and piles before and during driving.
2. Predrilling, **as directed**: Provide pre-excavated holes where indicated, to depths indicated. Drill holes with a diameter less than the largest cross-section dimension of pile.
   a. Firmly seat pile in predrilled hole by driving with reduced energy before starting final driving.
3. Heaved Piles: Redrive heaved piles to tip elevation at least as deep as original tip elevation with a driving resistance at least as great as original driving resistance.
4. Driving Tolerances: Drive piles without exceeding the following tolerances, measured at pile heads:
   a. Location: 4 inches (102 mm) from location indicated after initial driving, and 6 inches (152 mm) after pile driving is completed.
   b. Plumb: Maintain 1 inch (25 mm) in 4 feet (1.2 m) from vertical, or a maximum of 4 inches (102 mm), measured when pile is aboveground in leads.
   c. Batter Angle: Maximum 1 inch (25 mm) in 4 feet (1.2 m) from required angle, measured when pile is aboveground in leads.
5. Withdraw damaged or defective piles and piles that exceed driving tolerances and install new piles within driving tolerances.
   a. Fill holes left by withdrawn piles using cohesionless soil material such as gravel, broken stone, and gravel-sand mixtures. Place and compact in lifts not exceeding 72 inches (1.83 m).
      OR
      Fill holes left by withdrawn piles as directed by the Owner.

   OR

   Abandon and cut off rejected piles as directed by the Owner. Leave rejected piles in place and install new piles in locations as directed by the Owner.
6. Cutting Off: Cut off tops of driven piles square with pile axis and at elevations indicated.
7. Pile-Driving Records: Maintain accurate driving records for each pile, compiled and attested to by a qualified professional engineer, **as directed**. Include the following data:
   a. Project name and number.
   b. Name of Contractor.
   c. Pile location in pile group and designation of pile group.
   d. Sequence of driving in pile group.
   e. Pile dimensions.
   f. Ground elevation.
   g. Elevation of tips after driving.
   h. Final tip and cutoff elevations of piles after driving pile group.
   i. Records of redriving.
   j. Elevation of splices.
   k. Type, make, model, and rated energy of hammer.
   l. Weight and stroke of hammer.
   m. Type of pile-driving cap used.
   n. Cushion material and thickness.
   o. Actual stroke and blow rate of hammer.
   p. Pile-driving start and finish times, and total driving time.
   q. Time, pile-tip elevation, and reason for interruptions.
   r. Number of blows for every 12 inches (305 mm) of penetration, and number of blows per 1 inch (25 mm) for the last 6 inches (152 mm) of driving.
   s. Pile deviations from location and plumb.
   t. Preboring, jetting, or special procedures used.
   u. Unusual occurrences during pile driving.

E. Field Quality Control

1. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
   a. Pile foundations.
2. Testing Agency: Engage a qualified independent testing agency to perform tests and inspections.
3. Tests and Inspections:
   a. Dynamic Pile Testing: High-strain dynamic monitoring shall be performed and reported according to ASTM D 4945 during initial driving and during restriking on five single piles **OR** 3 percent of piles, **as directed**.
   b. Weld Testing: In addition to visual inspection, welds shall be tested and inspected according to AWS D1.1/D1.1M and inspection procedures listed below, at testing agency's option. Correct deficiencies in Work that test reports and inspections indicate do not comply with the Contract Documents.
      1) Liquid Penetrant Inspection: ASTM E 165.
      2) Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
      3) Radiographic Inspection: ASTM E 94, minimum quality level "2-2T."
      4) Ultrasonic Inspection: ASTM E 164.

F. Touchup Painting, **as directed**
   1. Clean field welds, splices, and abraded painted areas and field-apply paint according to SSPC-PA 1. Use same paint and apply same number of coats as specified for shop painting.
      a. Apply touchup paint before driving piles to surfaces that will be immersed or inaccessible after driving.

G. Disposal
   1. Remove withdrawn piles and cutoff sections of piles from site and legally dispose of them off Owner's property.

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SECTION 31 62 16 19 - CONCRETE-FILLED STEEL PILES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for concrete-filled steel piles. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes concrete-filled steel shell and pipe piles.

C. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For composite piles. Show fabrication and installation details for piles, including splices and tip details.
   a. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld.
   b. Indicate locations, sizes, type, and arrangement of reinforcement.
   c. Include arrangement of static pile reaction frame, test and anchor piles, equipment, and instrumentation. Submit structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Welding certificates.
4. Design Mixes: For each concrete mix. Include revised mix proportions when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
5. Material Certificates: For steel shell piles and accessories, steel pipe piles and accessories, steel reinforcement and concrete admixtures, from manufacturer.
6. Material Test Reports: For concrete materials.
7. Pile-Driving Equipment Data: Include type, make, and rated energy range; weight of striking part of hammer; weight of drive cap; and, type, size, and properties of hammer cushion.
   a. Include mandrel type and details.
8. Static Pile Test Reports: Submit within three days of completing each test.
9. Pile-Driving Records: Submit within three days of driving each pile.
10. Field quality-control reports.
11. Preconstruction Photographs: Photographs or video of existing conditions of adjacent construction. Submit before the Work begins.

D. Quality Assurance
1. Testing Agency Qualifications: An independent testing agency qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
2. Comply with requirements in ACI 301, "Specifications for Structural Concrete."
3. Welding Qualifications: Qualify procedures and personnel according to the following:
   a. AWS D1.1/D1.1M, "Structural Welding Code - Steel"
   b. AWS D1.3, "Structural Welding Code - Sheet Steel."
4. Preinstallation Conference: Conduct conference at Project site.

E. Delivery, Storage, And Handling
1. Deliver piles to Project site in such quantities and at such times to ensure continuity of installation. Handle and store piles at Project site to prevent physical damage.
   a. Painted Piles: Protect finish and touch up damage before driving piles.

F. Project Conditions

1. Protect structures, underground utilities, and other construction from damage caused by pile driving.
2. Preconstruction Photographs: Inventory and record the condition of adjacent structures, underground utilities, and other construction. Provide photographs **OR** video, **as directed**, of conditions that might be misconstrued as damage caused by pile driving.

1.2 PRODUCTS

A. Steel Shell Piles
1. Fluted Pile Shells: Manufacturer's standard, vertically fluted pile shells; cold formed from steel sheet; 50,000-psi (345-MPa) minimum yield strength after forming. Fabricate watertight, uniformly tapered sections with forged-steel conical nose welded to tip.
   a. Constant Diameter Extensions: Fabricate with splice overlap capable of telescoping into tapered section.
   b. Taper: 0.14 inch in 12 inches (1:86) **OR** 0.25 inch in 12 inches (1:48) **OR** 0.40 inch in 12 inches (1:30), **as directed**.
   c. Thickness: 0.150 inch (3.80 mm) **OR** 0.179 inch (4.55 mm) **OR** 0.209 inch (5.31 mm) **OR** 0.239 inch (6.07 mm), **as directed**.
2. Helically Corrugated Pile Shells: Manufacturer's standard, helically corrugated, uniform-diameter, steel sheet shell piles; of sufficient strength and thickness to remain watertight and resist distortion and buckling due to soil pressure, internal mandrel operation, or redriving. Fabricate in one-piece lengths with 3/16-inch- (4.76-mm-) thick, minimum steel-plate boot continuously welded to tip and as follows:
   a. Nominal Diameter: 8-5/8 inches (219 mm) **OR** 10-5/8 inches (270 mm) **OR** 11-1/8 inches (283 mm) **OR** 12-1/4 inches (311 mm) **OR** 14 inches (350 mm) **OR** 16-1/8 inches (410 mm), **as directed**.
   b. Thickness: 0.048 inch (1.21 mm), minimum **OR** 0.060 inch (1.52 mm), minimum **OR** 0.075 inch (1.90 mm), minimum **OR** 0.105 inch (2.66 mm), **as directed**.

B. Steel Pipe Piles
1. Steel Pipe: ASTM A 252, Grade 2 **OR** Grade 3, **as directed**; seamless or welded.

C. Steel Reinforcement
1. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420); deformed.
2. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M.
3. Galvanized Reinforcing Bars: ASTM A 767/A 767M, Class II zinc coated, hot-dip galvanized after fabrication and bending, as follows:
   a. Steel Reinforcement: ASTM A 615/A 615M, Grade 60 (Grade 420) **OR** ASTM A 706/A 706M, **as directed**; deformed.
4. Epoxy-Coated Reinforcing Bars: ASTM A 775/A 775M or ASTM A 934/A 934M, as follows:
   a. Steel Reinforcement: ASTM A 615/A 615M, Grade 60 (Grade 420) **OR** ASTM A 706/A 706M, **as directed**; deformed.
5. Plain Steel Wire: ASTM A 82/A 82M, as drawn **OR** galvanized, **as directed**.
6. Deformed-Steel Wire: ASTM A 496/A 496M.
7. Epoxy-Coated-Steel Wire: ASTM A 884/A 884M, Class A coated, plain **OR** deformed, **as directed**.

D. Concrete Materials
1. Portland Cement: ASTM C 150, Type I or II.
   a. Fly Ash: ASTM C 618, Class C or F.
   b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
2. Blended Hydraulic Cement: ASTM C 595, Type IS, portland blast-furnace slag **OR** Type IP, portland-pozzolan **OR** Type I (PM), pozzolan-modified portland **OR** Type I (SM), slag-modified Portland, **as directed**, cement.

3. Normal-Weight Aggregates: ASTM C 33, Class 4S **OR** Class 4M **OR** Class 1N, **as directed**, uniformly graded, 3/4-inch (19-mm) maximum aggregate size. Provide aggregates from a single source.
4. Water: Potable, complying with ASTM C 94/C 94M requirements.
5. Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent chloride ions by mass of cementitious material.
   a. Air-Entraining Admixture: ASTM C 260.
   b. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
   c. Retarding Admixture: ASTM C 494/C 494M, Type B.
   d. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
   e. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
   f. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
   g. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

E. Pile Accessories
1. Driving Points: Manufacturer's standard 60-degree conical driving point, with integral reinforcing ribs, to provide full bearing of pipe pile tip. Fabricate from steel castings as follows:
2. Inside Cutting Shoes: Manufacturer's standard, inside-flanged, open-ended cutting shoe, to provide full bearing of pipe pile tip. Fabricate from steel castings as follows:
3. Outside Cutting Shoes: Manufacturer's standard, outside-flanged, open-ended cutting shoe, to provide full bearing of pipe pile tip. Fabricate from steel castings as follows:
   a. Carbon-Steel Castings: ASTM A 27/A 27M, Grade 65-35 (Grade 450-240), heat treated **OR** Grade N1, **as directed**.
   b. High-Strength Steel Castings: ASTM A 148/A 148M, Grade 80-40 (Grade 550-275) **OR** Grade 90-60 (Grade 620-415), **as directed**.
4. Splice Coupling: Manufacturer's standard splice coupling, rolled from ASTM A 36/A 36M, carbon-steel bar or cast from heat-treated carbon steel, ASTM A 27/A 27M, Grade 65-35 (Grade 450-240), with interior stop and internally tapered for friction fit driving.

F. Paint
1. Paint: SSPC-Paint 16; self-priming, two-component, coal-tar epoxy polyamide, black **OR** red **OR** manufacturer's standard color, **as directed**.

G. Concrete Mixes
1. Prepare concrete design mixes according to ACI 301, determined by either laboratory trial batch or field test data basis.
   a. Use a qualified testing agency for preparing and reporting proposed mix designs determined by laboratory trial batch.
2. Proportion mixes according to ACI 301 to provide normal-weight concrete suitable for piles with the following properties:
   a. Compressive Strength (28 Days): 5000 psi (34.5 MPa) **OR** 4000 psi (27.6 MPa) **OR** 3000 psi (20.7 MPa), **as directed**.
   b. Maximum Water-Cementitious Material Ratio at Point of Placement: 0.45 **OR** 0.50, **as directed**.
   c. Slump Limit: 5 inches (127 mm) **OR** 8 inches (203 mm), **as directed**, plus or minus 1 inch (25 mm).
3. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content of 6.0 percent, plus or minus 1.5 **OR** 2.5 to 4.5, **as directed**, percent.
4. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 limits as if concrete were exposed to deicing chemicals.
5. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 **OR** 0.30, **as directed**, percent by weight of cement.
6. Concrete-mix design adjustments may be considered if characteristics of materials, Project conditions, weather, test results, or other circumstances warrant. Resubmit and obtain approval from the Owner of proposed changes to concrete-mix proportions.

H. Fabrication
1. Fabricate and assemble piles in shop to greatest extent possible.
2. Fabricate full-length piles to eliminate splicing during driving.
OR
Fabricate full-length piles by splicing pile lengths together. Maintain axial alignment of pile lengths. Maintain structural properties of pile across splice.
a. Splice Coupling: Fit splice coupling into position and weld to adjoining steel pipe pile sections according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.
b. Welded Splices: Accurately mill meeting ends of steel pipe piles and bevel for welding. Continuously weld pile according to AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.
c. Welded Splices: Continuously weld steel shell pile according to manufacturer's written instructions and AWS D1.1/D1.1M and AWS D1.3, **as directed**, for procedures, appearance and quality of welds, and methods used in correcting welding work.
d. Splice piles during fabrication or field installation.
3. Fit and weld driving points to tip of pile according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.
OR
Fit and weld cutting shoes to tip of pile according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.
4. Pile-Length Markings: Mark each pile with horizontal lines at 12-inch (305-mm) intervals; label the distance from pile tip at 60-inch (1.52-m) intervals. Maintain markings on piles until driven.

I. Shop Painting, **as directed**
1. General: Shop paint steel pile surfaces, except for surfaces to be encased in concrete, as follows:
a. Extend painting to a depth of 60 inches (1.52 m) below finished grade **OR** low-tide level, **as directed**, to top of exposed pile.
2. Surface Preparation: Clean surfaces to be painted. Remove loose rust and loose mill scale, and remove spatter, slag, or flux deposits. Prepare surfaces according to SSPC-SP 10/NACE No. 2, "Near-White Blast Cleaning."
3. Painting: Immediately after surface preparation, apply coat of paint according to manufacturer's written instructions to provide a dry film thickness of not less than 8 mils (0.2 mm).
a. Apply second coat to provide a dry film thickness of not less than 8 mils (0.2 mm), resulting in a two-coat paint system thickness of not less than 16 mils (0.4 mm).
b. Apply second and third coats with each coat having a dry film thickness of not less than 8 mils (0.2 mm), resulting in a three-coat paint system thickness of not less than 24 mils (0.6 mm).
c. Mark pile lengths after shop painting.

J. Concrete Mixing
1. Ready-Mixed Concrete: Comply with ASTM C 94/C 94M.
a. Do not add water to concrete mix after mixing.
b. Maintain concrete temperature to not exceed 90 deg F (32 deg C).

1.3 EXECUTION

A. Examination

1. Site Conditions: Do not start pile-driving operations until earthwork fills have been completed or excavations have reached an elevation of 6 to 12 inches (152 to 305 mm) above bottom of footing or pile cap.

B. Driving Equipment
1. Pile Hammer: Air-, steam-, hydraulic-, or diesel-powered type capable of consistently delivering adequate peak-force duration and magnitude to develop the ultimate capacity required for type and size of pile driven and character of subsurface material anticipated.
2. Hammer Cushions and Driving Caps: Between hammer and top of pile, provide hammer cushion and steel driving cap as recommended by hammer manufacturer and as required to drive pile without damage.
3. Leads: Use fixed, semifixed, or hanging-type pile-driver leads that will hold full length of pile firmly in position and in axial alignment with hammer.
4. Mandrel: Expandable mandrel, capable of distributing driving energy throughout length of steel shell pile.

C. Static Pile Tests, **as directed**
1. General: Static pile tests will be used to verify driving criteria and pile lengths and to confirm allowable load of piles.
   a. Furnish test piles 60 inches (1.52 m) longer than production piles.
   b. Determination of actual length of piles will be based on results of static pile tests.
2. Pile Tests: Arrange and perform the following pile tests:
   a. Axial Compressive Static Load Test: ASTM D 1143.
   b. Axial Tension Static Load Test: ASTM D 3689.
   c. Lateral Load Test: ASTM D 3966.
3. Equip each test pile with two telltale rods, according to ASTM D 1143, for measuring deformation during load test.
4. Provide pile reaction frame, anchor piles, equipment, and instrumentation with sufficient reaction capacity to perform tests. Notify the Owner at least 48 hours in advance of performing tests. On completion of testing, remove testing structure, anchor piles, equipment, and instrumentation.
   a. Allow a minimum of seven days to elapse after driving test piles before starting pile testing.
   b. Number of Test Piles: One pile **OR** As indicated, **as directed**.
5. Driving Test Piles: Drive test piles at locations indicated to the minimum penetration or driving resistance indicated. Use test piles identical to those required for Project and drive with appropriate pile-driving equipment operating at rated driving energy to be used in driving permanent piles.
   a. Pile Design Load: As indicated **OR as directed**.
6. Approval Criteria: Allowable load shall be the load acting on the test pile when the lesser of, **as directed**, the following criteria are met, divided by a factor of safety of 2:
   a. Net settlement, after deducting rebound, of not more than 0.01 inch/ton (0.25 mm/907 kg) of test load.
   b. Total settlement exceeds the pile elastic compression by 0.15 inch (4 mm), plus 1.0 percent of the tip diagonal dimension.
   c. A plunging failure or sharp break in the load settlement curve.
7. Test Pile-Driving Records: Prepare driving records for each test pile, compiled and attested to by a qualified professional engineer, **as directed**. Include same data as required for driving records of permanent piles.
8. Test piles that comply with requirements, including location tolerances, may be used on Project.

D. Steel Reinforcement
1. Comply with recommendations in CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
2. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy bond with concrete.
3. Fabricate and install reinforcement cages symmetrically about axis of pile shell **OR** pipe, **as directed**, in a single unit.

4. Accurately position, support, and secure reinforcement against displacement during concreting. Maintain minimum cover on reinforcement.
5. Protect exposed ends of extended reinforcement, dowels, or anchor bolts from mechanical damage and exposure to weather.

E. Concrete Placement
1. Do not place concrete until other piles within a radius of 20 feet (6 m) have been driven and approved.
2. Inspection: Before placing concrete, allow testing and inspecting agency to visually inspect and verify that each pile shell **OR** pipe, **as directed**, is clean, watertight, plumb, and free of distortion or other defects.
3. Place concrete in a continuous operation and without segregation immediately after cleaning out pile shell **OR** pipe, **as directed**.
4. Place concrete by means of bottom discharge bucket, flexible drop chute, steep-sided funnel hopper, or tremie or pump concrete into place.
5. Place concrete in a dry pile shell **OR** pipe, **as directed**, unless placement underwater is approved by the Owner.
   a. Place concrete underwater by tremie method or pumping. Control placement operations to ensure tremie is embedded no less than 60 inches (1.52 m) into concrete, and flow of tremied concrete is continuous from bottom to top of pile shell **OR** pipe, **as directed**.
   b. Other methods of depositing concrete may be used if approved by the Owner.
6. Consolidate final 10 feet (3 m) of concrete during placement to ensure that concrete is thoroughly worked around steel reinforcement and into corners.
7. Screed concrete level at cutoff elevation and apply a scoured, rough finish.

F. Driving Piles
1. General: Continuously drive piles to elevations or penetration resistance indicated or established by static load testing of piles, **as directed**. Establish and maintain axial alignment of leads and piles before and during driving.
2. Predrilling, **as directed**: Provide pre-excavated holes where indicated, to depths indicated. Drill holes with a diameter less than the largest cross-section dimension of pile.
   a. Firmly seat pile in predrilled hole by driving with reduced energy before starting final driving.
3. Heaved Piles: Redrive heaved piles to tip elevation at least as deep as original tip elevation with a driving resistance at least as great as original driving resistance.
4. Pile Splices: Splice piles during installation and align pile segments concentrically.
5. Driving Tolerances: Drive piles without exceeding the following tolerances, measured at pile heads:
   a. Location: 4 inches (102 mm) from location indicated after initial driving, and 6 inches (152 mm) after pile driving is completed.
   b. Plumb: Maintain 1 inch (25 mm) in 4 feet (1.2 m) from vertical, or a maximum of 4 inches (102 mm), measured when pile is aboveground in leads.
   c. Batter Angle: Maximum 1 inch (25 mm) in 4 feet (1.2 m) from required angle, measured when pile is aboveground in leads.
6. Excavation: Clean out steel pipe pile by removing soil and debris from inside pile before placing steel reinforcement or concrete.
7. Withdraw damaged or defective piles and piles that exceed driving tolerances and install new piles within driving tolerances.
   a. Fill holes left by withdrawn piles using cohesionless soil material such as gravel, broken stone, and gravel-sand mixtures. Place and compact in lifts not exceeding 72 inches (1.83 m).
      OR
      Fill holes left by withdrawn piles as directed by the Owner.

   OR

Abandon and cut off rejected piles as directed by the Owner. Leave rejected piles in place and install new piles in locations as directed by the Owner.

8. Cutting Off: Cut off tops of driven piles square with pile axis and at elevations indicated.
9. Pile-Driving Records: Maintain accurate driving records for each pile, compiled and attested to by a qualified professional engineer, **as directed**. Include the following data:
   a. Project name and number.
   b. Name of Contractor.
   c. Pile location in pile group and designation of pile group.
   d. Sequence of driving in pile group.
   e. Pile dimensions.
   f. Ground elevation.
   g. Elevation of tips after driving.
   h. Final tip and cutoff elevations of piles after driving pile group.
   i. Records of redriving.
   j. Elevation of splices.
   k. Type, make, model, and rated energy of hammer.
   l. Weight and stroke of hammer.
   m. Type of pile-driving cap used.
   n. Cushion material and thickness.
   o. Actual stroke and blow rate of hammer.
   p. Pile-driving start and finish times, and total driving time.
   q. Time, pile-tip elevation, and reason for interruptions.
   r. Number of blows for every 12 inches (305 mm) of penetration, and number of blows per 1 inch (25 mm) for the last 6 inches (152 mm) of driving.
   s. Pile deviations from location and plumb.
   t. Preboring, jetting, or special procedures used.
   u. Unusual occurrences during pile driving.

G. Field Quality Control
1. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
   a. Pile foundations.
2. Testing Agency: Engage a qualified independent testing agency to perform tests and inspections.
3. Tests and Inspections:
   a. Dynamic Pile Testing: High-strain dynamic monitoring shall be performed and reported according to ASTM D 4945 during initial driving and during restriking on 5 single piles **OR** 3 percent of piles, **as directed**.
   b. Low-strain integrity measurement shall be performed and reported for each pile.
   c. Weld Testing: In addition to visual inspection, welds shall be tested and inspected according to AWS D1.1/D1.1M and the inspection procedures listed in subparagraphs below, at testing agency's option. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.
      1) Liquid Penetrant Inspection: ASTM E 165.
      2) Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
      3) Radiographic Inspection: ASTM E 94; minimum quality level "2-2T."
      4) Ultrasonic Inspection: ASTM E 164.
   d. Concrete: Sampling and testing of concrete for quality control shall include the following:
      1) Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94/C 94M.
         a) Slump: ASTM C 143/C 143M; one test at point of placement for each compressive-strength test, but no fewer than one test for each concrete load.
         b) Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F (5 deg C) and below or when 80 deg F (27 deg C) and above, and one test for each set of compressive-strength specimens.

c) Compression Test Specimens: ASTM C 31/C 31M; one set of four standard cylinders for each compressive-strength test unless otherwise indicated. Mold and store cylinders for laboratory-cured test specimens unless field-cured test specimens are required.

d) Compressive-Strength Tests: ASTM C 39/C 39M; one set for each truck load. One specimen shall be tested at seven days, two specimens shall be tested at 28 days, and one specimen shall be retained in reserve for later testing if required.

2) When frequency of testing will provide fewer than five strength tests for a given class of concrete, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

3) When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing in-place concrete.

4) Strength level of concrete will be considered satisfactory if averages of sets of three consecutive strength test results equal or exceed specified compressive strength and no individual strength test result falls below specified compressive strength by more than 500 psi (3.45 MPa).

5) Test results shall be reported in writing to the Owner, concrete manufacturer, and Contractor within 24 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, concrete type and class, location of concrete batch in piles, design compressive strength at 28 days, concrete-mix proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

6) Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted but shall not be used as sole basis for acceptance or rejection.

7) Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate concrete strengths or other requirements have not been met.

H. Touchup Painting, a**s directed**

1. Clean field welds, splices, and abraded painted areas and field-apply paint according to SSPC-PA 1. Use same paint and apply same number of coats as specified for shop painting.
   a. Apply touchup paint before driving piles to surfaces that will be immersed or inaccessible after driving.

I. Disposal

1. Remove withdrawn piles and cutoff sections of piles from site and legally dispose of them off Owner's property.

END OF SECTION 31 62 16 19

SECTION 31 62 19 00 - TIMBER PILES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for timber piles. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes round timber piles.

C. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For timber piles. Show fabrication and installation details for piles, including details of driving shoes, tips or boots, and pile butt protection.
   a. Include arrangement of static pile reaction frame, test and anchor piles, equipment, and instrumentation. Submit structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Round timber pile treatment data as follows, including chemical treatment manufacturer's written instructions for handling, storing, installing, and finishing treated material:
   a. For each type of preservative-treated timber product include certification by treating plant stating type of preservative solution and pressure process used, net amount of preservative retained, and compliance with applicable standards.
   b. For waterborne-treated products include statement that moisture content of treated materials was reduced to levels indicated before shipment to Project site.
4. Pile-Driving Equipment Data: Include type, make, and rated energy range; weight of striking part of hammer; weight of drive cap; and, type, size, and properties of hammer cushion.
5. Static Pile Test Reports: Submit within three days of completing each test.
6. Pile-Driving Records: Submit within three days of driving each pile.
7. Field quality-control reports.
8. Warranty of chemical treatment manufacturer for each type of treatment.
9. Preconstruction Photographs: Photographs or video of existing conditions of adjacent construction. Submit before the Work begins.

D. Quality Assurance
1. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.
2. Preinstallation Conference: Conduct conference at Project site.

E. Delivery, Storage, And Handling
1. Deliver piles to Project site in such quantities and at such times to ensure continuity of installation. Handle and store piles at Project site to prevent breaks, cuts, abrasions, or other physical damage and as required by AWPA M4.
   a. Do not drill holes or drive spikes or nails into pile below cutoff elevation.

F. Project Conditions
1. Protect structures, underground utilities, and other construction from damage caused by pile driving.
2. Preconstruction Photographs: Inventory and record the condition of adjacent structures, underground utilities, and other construction. Provide photographs **OR** video, **as directed**, of conditions that might be misconstrued as damage caused by pile driving.

1.2 PRODUCTS

A. Timber Piles
1. Round Timber Piles: ASTM D 25, unused, clean peeled, one piece from butt to tip; of the following species and size basis:
a. Species: Coastal Douglas fir **OR** Southern yellow pine, **as directed**.
b. Size Basis: Butt circumference **OR** Class A **OR** Class B **OR** Tip circumference **OR** 8-inch (203-mm) tip and natural taper, **as directed**.
2. Pressure-treat round timber piles according to AWPA C3 and, **as directed**, AWPA C18 **OR** AWPA C14, **as directed**, as follows:
a. Service Condition: Land and freshwater **OR** Foundation **OR** Saltwater **OR** Marine piles - dual treatment, **as directed**.
b. Treatment: Waterborne preservative **OR** Creosote or creosote solution **OR** Oil-borne preservative **OR** Waterborne preservative, severe marine borer hazard **OR** Dual treatment consisting of waterborne preservative, followed by creosote or creosote solution, **as directed**.

B. Pile Accessories
1. Driving Shoes: Fabricate from ASTM A 1011/A 1011M, hot-rolled carbon-steel strip to suit pile-tip diameter, of the following type and thickness, and secure to pile tip so as to not affect pile alignment during driving:
a. Type: Flat boot **OR** Arrow point, **as directed**.
b. Thickness: 3/16 inch (4.8 mm) **OR** 1/4 inch (6 mm), **as directed**.

C. Fabrication
1. Pile Tips: Cut and shape pile tips to accept driving shoes. Fit and fasten driving shoes to pile tips according to manufacturer's written instructions.
2. Pile Butt: Trim pile butt and cut perpendicular to longitudinal axis of pile. Chamfer and shape butt to fit tightly to driving cap of hammer.
3. Field-Applied Wood Preservative: Treat field cuts, holes, and other penetrations according to AWPA M4.
a. Coal-tar roofing cement for treating drilled holes or sealing cutoffs shall be free of asbestos.
4. Pile Splices: Splices will not be permitted.
5. Pile-Length Markings: Mark each pile with horizontal lines at 12-inch (305-mm) intervals; label the distance from pile tip at 60-inch (1.52-m) intervals. Maintain markings on piles until driven.

1.3 EXECUTION

A. Examination
1. Site Conditions: Do not start pile-driving operations until earthwork fills have been completed or excavations have reached an elevation of 6 to 12 inches (152 to 305 mm) above bottom of footing or pile cap.

B. Driving Equipment
1. Pile Hammer: Air-, steam-, hydraulic-, or diesel-powered type capable of consistently delivering adequate peak-force duration and magnitude to develop the ultimate capacity required for type and size of pile driven and character of subsurface material anticipated.
2. Hammer Cushions and Driving Caps: Between hammer and top of pile, provide hammer cushion and steel driving cap as recommended by hammer manufacturer and as required to drive pile without damage.
3. Leads: Use fixed, semifixed, or hanging-type pile-driver leads that will hold full length of pile firmly in position and in axial alignment with hammer.

C. Static Pile Tests, **as directed**

1. General: Static pile tests will be used to verify driving criteria and pile lengths and to confirm allowable load of piles.
   a. Furnish test piles 60 inches (1.52 m) longer than production piles.
   b. Determination of actual length of piles will be based on results of static pile tests.
2. Pile Tests: Arrange and perform the following pile tests:
   a. Axial Compressive Static Load Test: ASTM D 1143.
   b. Axial Tension Static Load Test: ASTM D 3689.
   c. Lateral Load Test: ASTM D 3966.
3. Equip each test pile with two telltale rods, according to ASTM D 1143, for measuring deformation during load test.
4. Provide pile reaction frame, anchor piles, equipment, and instrumentation with sufficient reaction capacity to perform tests. Notify the Owner at least 48 hours in advance of performing tests. On completion of testing, remove testing structure, anchor piles, equipment, and instrumentation.
   a. Allow a minimum of seven days to elapse after driving test piles before starting pile testing.
   b. Number of Test Piles: One pile **OR** As indicated, **as directed**.
5. Driving Test Piles: Drive test piles at locations indicated to the minimum penetration or driving resistance indicated. Use test piles identical to those required for Project and drive with appropriate pile-driving equipment operating at rated driving energy to be used in driving permanent piles.
6. Approval Criteria: Allowable load shall be the load acting on the test pile when the lesser of, **as directed**, the following criteria are met, divided by a factor of safety of 2:
   a. Net settlement, after deducting rebound, of not more than 0.01 inch/ton (0.25 mm/907 kg) of test load.
   b. Total settlement exceeds the pile elastic compression by 0.15 inch (4 mm), plus 1.0 percent of the tip diagonal dimension.
   c. A plunging failure or sharp break in the load settlement curve.
7. Test Pile-Driving Records: Prepare driving records for each test pile, compiled and attested to by a qualified professional engineer, **as directed**. Include same data as required for driving records of permanent piles.
8. Test piles that comply with requirements, including location tolerances, may be used on Project.

D. Driving Piles

1. General: Continuously drive piles to elevations or penetration resistance indicated or established by static load testing of piles, **as directed**. Establish and maintain axial alignment of leads and piles before and during driving.
2. Spudding: Drive spud piles through overlying highly resistant strata or obstructions and withdraw for reuse.
3. Predrilling, **as directed**: Provide pre-excavated holes where indicated, to depths indicated. Drill holes with a diameter less than the largest cross-section dimension of pile.
   a. Firmly seat pile in predrilled hole by driving with reduced energy before starting final driving.
4. Heaved Piles: Redrive heaved piles to tip elevation at least as deep as original tip elevation with a driving resistance at least as great as original driving resistance.
5. Driving Tolerances: Drive piles without exceeding the following tolerances, measured at pile heads:
   a. Location: 4 inches (102 mm) from location indicated after initial driving, and 6 inches (152 mm) after pile driving is completed.
   b. Plumb: Maintain 1 inch (25 mm) in 4 feet (1.2 m) from vertical, or a maximum of 4 inches (102 mm), measured when pile is aboveground in leads.
   c. Batter Angle: Maximum 1 inch (25 mm) in 4 feet (1.2 m) from required angle, measured when pile is aboveground in leads.
6. Withdraw damaged or defective piles and piles that exceed driving tolerances and install new piles within driving tolerances.

a. Fill holes left by withdrawn piles using cohesionless soil material such as gravel, broken stone, and gravel-sand mixtures. Place and compact in lifts not exceeding 72 inches (1.83 m).
OR
Fill holes left by withdrawn piles as directed by the Owner.

OR

Abandon and cut off rejected piles as directed by the Owner. Leave rejected piles in place and install new piles in locations as directed by the Owner.

7. Cutting Off: Cut off butts of driven piles square with pile axis and at elevations indicated.
   a. Cover cut-off piling surfaces with caps overlapping pile end by minimum 2 inches (51 mm) **OR** minimum three coats of preservative treatment, **as directed**, according to AWPA M4.
8. Pile-Driving Records: Maintain accurate driving records for each pile, compiled and attested to by a qualified professional engineer, **as directed**. Include the following data:
   a. Project name and number.
   b. Name of Contractor.
   c. Pile species.
   d. Pile location in pile group and designation of pile group.
   e. Sequence of driving in pile group.
   f. Pile dimensions.
   g. Ground elevation.
   h. Elevation of tips after driving.
   i. Final tip and cutoff elevations of piles after driving pile group.
   j. Records of redriving.
   k. Elevation of splices.
   l. Type, make, model, and rated energy of hammer.
   m. Weight and stroke of hammer.
   n. Type of pile-driving cap used.
   o. Cushion material and thickness.
   p. Actual stroke and blow rate of hammer.
   q. Pile-driving start and finish times, and total driving time.
   r. Time, pile-tip elevation, and reason for interruptions.
   s. Number of blows for every 12 inches (305 mm) of penetration, and number of blows per 1 inch (25 mm) for the last 6 inches (152 mm) of driving.
   t. Pile deviations from location and plumb.
   u. Preboring, jetting, or special procedures used.
   v. Unusual occurrences during pile driving.

E. Field Quality Control
1. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
   a. Pile foundations.
2. Testing Agency: Engage a qualified independent testing agency to perform tests and inspections.
3. Tests and Inspections:
   a. Dynamic Pile Testing: High-strain dynamic monitoring shall be performed and reported according to ASTM D 4945 during initial driving and during restriking on five single piles **OR** 3 percent of piles, **as directed**.

F. Disposal
1. Remove withdrawn piles and cutoff sections of piles from site and legally dispose of them off Owner's property.

END OF SECTION 31 62 19 00

Task	Specification	Specification Description
31 62 23 13	31 62 16 19	Concrete-Filled Steel Piles

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SECTION 31 64 13 00 - DRILLED PIERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for drilled piers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Dry-installed drilled piers.
b. Slurry displacement-installed drilled piers.

C. Submittals
1. Product Data: For each type of product indicated.
2. Design Mixtures: For each concrete mixture.
3. Shop Drawings: For concrete reinforcement.
4. Welding certificates.
5. Material certificates **OR** test reports, **as directed**.

D. Quality Assurance
1. Welding Qualifications: Qualify procedures and personnel according to the following:
a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
b. AWS D1.4, "Structural Welding Code - Reinforcing Steel."
2. Drilled-Pier Standard: Comply with ACI 336.1 unless modified in this Section.
3. Preinstallation Conference: Conduct conference at Project site.

E. Project Conditions
1. Existing Utilities: Locate existing underground utilities before excavating drilled piers. If utilities are to remain in place, provide protection from damage during drilled-pier operations.
a. Should uncharted or incorrectly charted piping or other utilities be encountered during excavation, adapt drilling procedure if necessary to prevent damage to utilities. Cooperate with the Owner and utility companies in keeping services and facilities in operation without interruption. Repair damaged utilities to satisfaction of utility the Owner.
2. Interruption of Existing Utilities: Do not interrupt any utility to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
a. Notify the Owner no fewer than two days in advance of proposed interruption of utility.
b. Do not proceed with interruption of utility without the Owner's written permission.
3. Survey Work: Engage a qualified land surveyor or professional engineer to perform surveys, layouts, and measurements for drilled piers. Before excavating, lay out each drilled pier to lines and levels required. Record actual measurements of each drilled pier's location, shaft diameter, bottom and top elevations, deviations from specified tolerances, and other specified data.
a. Record and maintain information pertinent to each drilled pier and cooperate with the Owner's testing and inspecting agency to provide data for required reports.

1.2 PRODUCTS

A. Steel Reinforcement
1. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.
2. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, deformed.

3. Galvanized Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420) **OR** ASTM A 706/A 706M, **as directed**, deformed bars, ASTM A 767/A 767M, Class I **OR** Class II, **as directed**, zinc coated after fabrication and bending.
4. Epoxy-Coated Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420) **OR** ASTM A 706/A 706M, **as directed**, deformed bars, ASTM A 775/A 775M or ASTM A 934/A 934M, epoxy coated, with less than 2 percent damaged coating in each 12-inch (300-mm) bar length.
5. Plain-Steel Wire: ASTM A 82, as drawn **OR** galvanized, **as directed**.
6. Deformed-Steel Wire: ASTM A 496.
7. Epoxy-Coated Wire: ASTM A 884/A 884M, Class A, Type 1 coated, as-drawn, plain **OR** deformed, **as directed**,-steel wire, with less than 2 percent damaged coating in each 12-inch (300-mm) wire length.
8. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), plain. Cut bars true to length with ends square and free of burrs.

B. Concrete Materials
1. Cementitious Material: Use the following cementitious materials, of same type, brand, and source, throughout Project:
   a. Portland Cement: ASTM C 150, Type I **OR** Type II **OR** Type I/II **OR** Type III **OR** Type V, **as directed**. Supplement with the following, **as directed**:
      1) Fly Ash: ASTM C 618, Class C **OR** Class F, **as directed**.
      2) Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
   b. Blended Hydraulic Cement: ASTM C 595, Type IS, portland blast-furnace slag **OR** Type IP, portland-pozzolan **OR** Type I (PM), pozzolan-modified portland **OR** Type I (SM), slag-modified Portland, **as directed**, cement.
2. Normal-Weight Aggregate: ASTM C 33, graded, 3/4-inch- (19-mm-) nominal maximum coarse-aggregate size.
   a. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
3. Water: ASTM C 94/C 94M and potable.
4. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
   a. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
   b. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
   c. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
   d. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.
5. Sand-Cement Grout: Portland cement, ASTM C 150, Type II; clean natural sand, ASTM C 404; and water to result in grout with a minimum 28-day compressive strength of 1000 psi (6.9 MPa), of consistency required for application.

C. Steel Casings
1. Steel Pipe Casings: ASTM A 283/A 283M, Grade C, or ASTM A 36/A 36M, carbon-steel plate, with joints full-penetration welded according to AWS D1.1/D1.1M.
2. Corrugated-Steel Pipe Casings: ASTM A 929/A 929M, steel sheet, zinc coated.
3. Liners: Comply with ACI 336.1.

D. Slurry
1. Slurry: Pulverized bentonite, pulverized attapulgite, or polymers mixed with water to form stable colloidal suspension; complying with ACI 336.1 for density, viscosity, sand content, and pH.

E. Concrete Mixtures
1. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.
2. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 limits as if concrete were exposed to deicing chemicals.

3. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 **OR** 0.30, **as directed**, percent by weight of cement.
4. Proportion normal-weight concrete mixture as follows:
   a. Compressive Strength (28 Days): 6000 psi (41.4 MPa) **OR** 5000 psi (34.5 MPa) **OR** 4500 psi (31 MPa) **OR** 4000 psi (27.6 MPa) **OR** 3500 psi (24.1 MPa) **OR** 3000 psi (20.7 MPa), **as directed**.
   b. Maximum Water-Cementitious Materials Ratio: 0.50 **OR** 0.45 **OR** 0.40, **as directed**.
   c. Minimum Slump: Capable of maintaining the following slump until completion of placement:
      1) 4 inches (100 mm) for dry, uncased, or permanent-cased drilling method.
      2) 6 inches (150 mm) for temporary-casing drilling method.
      3) 7 inches (175 mm) for slurry displacement method.
   d. Air Content: Do not air entrain concrete.

F. Fabricating Reinforcement
1. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

G. Concrete Mixing
1. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M, and furnish batch ticket information.
   a. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

1.3 EXECUTION

A. Preparation
1. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, vibration, and other hazards created by drilled-pier operations.

B. Excavation
1. Unclassified Excavation: Excavate to bearing elevations regardless of character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions.
   a. Obstructions: Unclassified excavation may include removal of unanticipated boulders, concrete, masonry, or other subsurface obstructions. No changes in the Contract Sum or the Contract Time will be authorized for removal of obstructions.
2. Classified Excavation: Excavation is classified as standard excavation, special excavation, and obstruction removal and includes excavation to bearing elevations as follows:
   a. Standard excavation includes excavation accomplished with conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work.
   b. Special excavation includes excavation that requires special equipment or procedures above or below indicated depth of drilled piers where drilled-pier excavation equipment used in standard excavation, operating at maximum power, torque, and downthrust, cannot advance the shaft.
      1) Special excavation requires use of special rock augers, core barrels, air tools, blasting, or other methods of hand excavation.
      2) Earth seams, rock fragments, and voids included in rock excavation area will be considered rock for full volume of shaft from initial contact with rock.
   c. Obstructions: Payment for removing unanticipated boulders, concrete, masonry, or other subsurface obstructions that cannot be removed by conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work will be according to Contract provisions for changes in the Work.

3. Prevent surface water from entering excavated shafts. Conduct water to site drainage facilities.
4. Excavate shafts for drilled piers to indicated elevations. Remove loose material from bottom of excavation.
   a. Excavate bottom of drilled piers to level plane within 1:12 tolerance.
   b. Remove water from excavated shafts before concreting.
   c. Excavate rock sockets of dimensions indicated.
   d. Cut series of grooves about perimeter of shaft to height from bottom of shaft, vertical spacing, and dimensions indicated.
5. Notify and allow testing and inspecting agency to test and inspect bottom of excavation. If unsuitable bearing stratum is encountered, make adjustments to drilled piers as determined by the Owner.
   a. Do not excavate shafts deeper than elevations indicated unless approved by the Owner.
   b. Payment for additional authorized excavation will be according to Contract provisions for changes in the Work.
6. End-Bearing Drilled Piers: If further exploration below bearing elevation is required for end-bearing piers or if soft soils are suspected, probe with auger to a depth below bearing elevation, equal to diameter of the bearing area of drilled pier. Determine whether voids, clay seams, or solution channels exist.
   a. Fill augur-probe holes with grout.
7. End-Bearing Drilled Piers: If drilled piers bear on clay or hardpan, probe with auger to a depth of 96 inches (2450 mm) below bottom elevation of shaft, and visually inspect and classify soil. Verify continuity and thickness of stratum.
8. Excavate shafts for closely spaced drilled piers and for drilled piers occurring in fragile or sand strata only after adjacent drilled piers are filled with concrete and allowed to set.
9. Slurry Displacement Method: Stabilize excavation with slurry maintained a minimum of 60 inches (1500 mm) above ground-water level and above unstable soil strata to prevent caving or sloughing of shaft. Maintain slurry properties before concreting.
   a. Excavate and complete concreting of drilled pier on same day if possible, or redrill, clean, and test slurry in excavation before concreting.
   b. Clean bottom of each shaft before concreting.
10. Temporary Casings: Install watertight steel casings of sufficient length and thickness to prevent water seepage into shaft; to withstand compressive, displacement, and withdrawal stresses; and to maintain stability of shaft walls.
    a. Remove temporary casings, maintained in plumb position, during concrete placement and before initial set of concrete, or leave temporary casings in place, **as directed**.
11. Bells: Excavate bells for drilled piers to shape, base thickness, and slope angle indicated. Excavate bottom of bells to level plane and remove loose material before placing concrete.
    a. Shore bells in unstable soil conditions to prevent cave-in during excavation, inspection, and concreting.
12. Tolerances: Construct drilled piers to remain within ACI 336.1 tolerances.
    a. If location or out-of-plumb tolerances are exceeded, provide corrective construction. Submit design and construction proposals to the Owner for review before proceeding.

C. Permanent Steel Casings
1. Install steel casings of minimum wall thickness indicated and of diameter not less than diameter of drilled pier.
   a. Install casings as excavation proceeds, to maintain sidewall stability.
   b. Fabricate bottom edge of lowest casing section with cutting shoe capable of penetrating rock and achieving water seal.
   c. Connect casing sections by continuous penetration welds to form watertight, continuous casing.
   d. Remove and replace or repair casings that have been damaged during installation and that could impair strength or efficiency of drilled pier.
   e. Fill annular void between casing and shaft wall with grout.

2. Corrugated-Steel Casings: Provide corrugated-steel casings formed from zinc-coated steel sheet.
   a. Corrugated casings may be delivered in sections or panels of convenient length and field connected according to manufacturer's written instructions.

D. Steel Reinforcement
1. Comply with recommendations in CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
2. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy bond with concrete.
3. Fabricate and install reinforcing cages symmetrically about axis of shafts in a single unit.
4. Accurately position, support, and secure reinforcement against displacement during concreting. Maintain minimum cover over reinforcement.
5. Use templates to set anchor bolts, leveling plates, and other accessories furnished in work of other Sections. Provide blocking and holding devices to maintain required position during final concrete placement.
6. Protect exposed ends of extended reinforcement, dowels, or anchor bolts from mechanical damage and exposure to weather.

E. Concrete Placement
1. Place concrete in continuous operation and without segregation immediately after inspection and approval of shaft by the Owner's independent testing and inspecting agency.
   a. Construct a construction joint if concrete placement is delayed more than one hour. Level top surface of concrete and insert joint dowel bars, **as directed**. Before placing remainder of concrete, clean surface laitance, roughen, and slush concrete with commercial bonding agent or with sand-cement grout mixed at ratio of 1:1.
2. Dry Method: Place concrete to fall vertically down the center of drilled pier without striking sides of shaft or steel reinforcement.
   a. Where concrete cannot be directed down shaft without striking reinforcement, place concrete with chutes, tremies, or pumps.
   b. Vibrate top 60 inches (1500 mm) of concrete.
3. Slurry Displacement Method: Place concrete in slurry-filled shafts by tremie methods or pumping. Control placement operations to ensure that tremie or pump pipe is embedded no fewer than 60 inches (1500 mm) into concrete and that flow of concrete is continuous from bottom to top of drilled pier.
4. Coordinate withdrawal of temporary casings with concrete placement to maintain at least a 60-inch (1500-mm) head of concrete above bottom of casing.
   a. Vibrate top 60 inches (1500 mm) of concrete after withdrawal of temporary casing.
5. Screed concrete at cutoff elevation level and apply scoured, rough finish. Where cutoff elevation is above the ground elevation, form top section above grade and extend shaft to required elevation.
6. Protect concrete work, according to ACI 301, from frost, freezing, or low temperatures that could cause physical damage or reduced strength.
   a. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
   b. Do not use calcium chloride, salt, or other mineral-containing antifreeze agents or chemical accelerators.
7. If hot-weather conditions exist that would seriously impair quality and strength of concrete, place concrete according to ACI 301 to maintain delivered temperature of concrete at no more than 90 deg F (32 deg C).
   a. Place concrete immediately on delivery. Keep exposed concrete surfaces and formed shaft extensions moist by fog sprays, wet burlap, or other effective means for a minimum of seven days.

F. Field Quality Control

1. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
   a. Drilled piers.
   b. Excavation.
   c. Concrete.
   d. Steel reinforcement welding.
2. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
3. Drilled-Pier Tests and Inspections: For each drilled pier, before concrete placement.
   a. Soil Testing: Bottom elevations, bearing capacities, and lengths of drilled piers indicated have been estimated from available soil data. Actual elevations and drilled-pier lengths and bearing capacities will be determined by testing and inspecting agency. Final evaluations and approval of data will be determined by the Owner.
      1) Bearing Stratum Tests: Testing agency will take undisturbed hardpan **OR** rock, **as directed**, core samples from drilled-pier bottoms and test each sample for compression, moisture content, and density, and will report results and evaluations.
4. Concrete Tests and Inspections: ASTM C 172 except modified for slump to comply with ASTM C 94/C 94M.
   a. Slump: ASTM C 143/C 143M; one test at point of placement for each compressive-strength test but no fewer than one test for each concrete load.
   b. Concrete Temperature: ASTM C 1064/C 1064M; 1 test hourly when air temperature is 40 deg F (4.4 deg C) and below and 80 deg F (27 deg C) and above, and 1 test for each set of compressive-strength specimens.
   c. Compression Test Specimens: ASTM C 31/C 31M; one set of four standard cylinders for each compressive-strength test unless otherwise indicated. Mold and store cylinders for laboratory-cured test specimens unless field-cured test specimens are required.
   d. Compressive-Strength Tests: ASTM C 39; one set for each drilled pier but not more than one set for each truck load. One specimen will be tested at 7 days, 2 specimens will be tested at 28 days, and 1 specimen will be retained in reserve for later testing if required.
   e. If frequency of testing will provide fewer than five strength tests for a given class of concrete, testing will be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
   f. If strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
   g. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa).
   h. Report test results in writing to the Owner, concrete manufacturer, and Contractor within 48 hours of testing. List Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests in reports of compressive-strength tests.
   i. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by the Owner but will not be used as sole basis for approval or rejection of concrete.
   j. Additional Tests: Testing and inspecting agency will make additional tests of concrete if test results indicate that slump, compressive strengths, or other requirements have not been met, as directed by the Owner.
      1) Continuous coring of drilled piers may be required, at Contractor's expense, if temporary casings have not been withdrawn within specified time limits or if observations of placement operations indicate deficient concrete quality, presence of voids, segregation, or other possible defects.

k. Perform additional testing and inspecting, at Contractor's expense, to determine compliance of replaced or additional work with specified requirements.
l. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.

5. An excavation, concrete, or a drilled pier will be considered defective if it does not pass tests and inspections.
6. Prepare test and inspection reports for each drilled pier as follows:
   a. Actual top and bottom elevations.
   b. Actual drilled-pier diameter at top, bottom, and bell.
   c. Top of rock elevation.
   d. Description of soil materials.
   e. Description, location, and dimensions of obstructions.
   f. Final top centerline location and deviations from requirements.
   g. Variation of shaft from plumb.
   h. Shaft excavating method.
   i. Design and tested bearing capacity of bottom.
   j. Depth of rock socket.
   k. Levelness of bottom and adequacy of cleanout.
   l. Properties of slurry and slurry test results at time of slurry placement and at time of concrete placement.
   m. Ground-water conditions and water-infiltration rate, depth, and pumping.
   n. Description, purpose, length, wall thickness, diameter, tip, and top and bottom elevations of temporary or permanent casings. Include anchorage and sealing methods used and condition and weather tightness of splices if any.
   o. Description of soil or water movement, sidewall stability, loss of ground, and means of control.
   p. Bell dimensions and variations from original design.
   q. Date and time of starting and completing excavation.
   r. Inspection report.
   s. Condition of reinforcing steel and splices.
   t. Position of reinforcing steel.
   u. Concrete placing method, including elevation of consolidation and delays.
   v. Elevation of concrete during removal of casings.
   w. Locations of construction joints.
   x. Concrete volume.
   y. Concrete testing results.
   z. Remarks, unusual conditions encountered, and deviations from requirements.

G. Disposal Of Surplus And Waste Materials
1. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off the Owner's property.

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SECTION 31 66 15 00 - RESISTANCE PIER SYSTEMS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of 2-Piece Resistance Piers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Scope of Work: The work includes, but is not limited, to the following:
1. All soil excavation;
2. Preparation of the footing and stem wall or foundation grade beam;
3. Installation of the Pier Bracket including concrete anchors;
4. Mounting of the Drive Stand Assembly and the installation of steel Pier Sections to designed specifications;
5. Installation of the Top Pier Platform and Two Piece Lift Head Assembly;
6. Lifting of the structure with hydraulic rams and the restoration of the structure to a permanent elevation;
7. Replacement of the soil and general site clean-up.

1.2 PRODUCTS

A. Pier Bracket
1. Standard 2-Piece Pier Bracket (2-7/8" Diameter Pier Pipe): The Pier Bracket shall be a welded assembly of 5/8 and 1/2 inch thick flame cut steel plates conforming to ASTM A36, A568 and A569. The Pier Bracket shall provide 69 square inches of bearing surface against the bottom of the footing and a minimum of 48 square inches against the vertical face of the foundation. The Pier Bracket shall have guides for the top pier platform, two 9/16 inch diameter bracket mounting holes, two 11/16 inch diameter pier pin holes and four 1-1/32 inch diameter alignment and equipment mounting holes.
2. Standard 2-Piece Pier Bracket (3-1/2" & 4" Diameter Pier Pipe): The Pier Bracket for the 3-1/2 inch or 4-inch diameter pier shall be a welded assembly of 5/8 and 1/2 inch thick flame cut steel plates conforming to ASTM A36, A568 and A569. The Pier Bracket shall provide 74 square inches of bearing surface against the bottom of the footing and a minimum of 59 square inches against the vertical face of the foundation. The Pier Bracket shall have guides for the Top Pier Platform, two 9/16 inch diameter bracket mounting holes, two 11/16 inch diameter pier pin holes and six 1-1/32 inch diameter alignment and equipment mounting holes.
3. Heavy Duty 2-Piece Pier Bracket (4-1/2" Diameter Pier Pipe): The Pier Bracket shall be a welded assembly of 5/8 and 1/2 inch thick flame cut steel plates conforming to ASTM A36, A568 and A569. The Pier Bracket shall provide 74 square inches of bearing surface against the bottom of the footing and a minimum of 128 square inches against the vertical face of the foundation. The Pier Bracket shall have guides for the Top Pier Platform, four 9/16 inch diameter bracket mounting holes, two 7/8 inch diameter pier pin holes and six 1-1/32 inch diameter alignment and equipment mounting holes.
4. Flat Plate 2-Piece Pier Bracket (2-7/8", 3-1/2" & 4" Diameter Pier Pipe): The Pier Bracket shall be a welded assembly of 5/8 and 1/2-inch thick flame cut steel plates conforming to ASTM A36, A568 and A569. The Pier Bracket shall provide 320 square inches of surface contact against a vertical face of the stem wall or column. The Pier Bracket shall have guides for the Top Pier Platform, four 1 inch and four 1-1/8 inch diameter bracket mounting holes, four 11/16 inch diameter pier pin holes and six 1-1/32 inch diameter alignment and equipment mounting holes.
5. Curved Plate 2-Piece Pier Bracket (2-7/8", 3-1/2 & 4" Diameter Pier Pipe): The Curved Plate series of Pier Brackets shall be constructed as specified in Paragraph A.1 above with the

exception that the plate that mounts against the circular column shall be rolled to conform to the diameter of the column.

B. Anchor Bolts
   1. Standard Pier Anchor Bolts: Each Pier Bracket requires two 1/2 inch diameter by 5-1/2 inch long (minimum) steel concrete expansion bolts (Four required for the 4-1/2" Diameter Heavy Duty 2-Piece Pier), cadmium plated with an ultimate pull out capacity of 6,300 pounds, working load 2,400 pounds. Bolts are required for mounting only. The Anchor Bolts shall be supplied with a flat washer and nut.
   2. Plate Pier Anchor Bolts: Each Pier Bracket requires two 1/2 inch diameter by 5-1/2 inch long (minimum), four 3/4 inch diameter by 7-1/2 inch long (minimum) and four 3/4 inch diameter (minimum) by 10 inch long (minimum) steel concrete expansion bolts, cadmium plated with an ultimate pull out capacity of 7,250 pounds (minimum) to achieve maximum capacity. (Lighter bolt design may be used with lighter load applications.) The Anchor Bolts shall be supplied with a flat washer and nut.

C. Grout (Optional)
   1. Pressure Bearing Grout: Quick setting premixed mortar with a 4,500 psi (minimum), three day strength. Master Builder's 713 Non-Shrink Grout or equivalent.
   2. Flowable Pipe Grout: Quick setting, neat cement flowable grout with a 4,000 psi (minimum), three day strength.
   3. Flowable Grout Fill: The grout slurry shall consist of sand, soil or other suitable void fill material mixed with any recognized lubricant such as 12 per cent cement (2-1/2 sack mix), bentonite or other lubricant to promote proper flow characteristics.

D. Drive Stand Assembly: The Drive Stand Assembly shall be a welded steel frame with a double acting hydraulic actuator capable of pressing the 42 inch long steel Pier Sections through the soil to a load bearing strata. The Drive Stand Assembly shall be temporarily attached to the Pier Bracket by means of one inch diameter by 2-3/4 inch long high strength locking pins.

E. Pier Section
   1. Pier Section (2-7/8" Diameter x 0.165" Wall Thickness): Each Pier Section shall be fabricated from a 2-7/8 inch outside diameter by 42-inch long mill rolled, induction heat treated steel section with a 0.165 inch wall thickness. Yield strength shall be 50,000 psi and tensile strength shall be 55,000 psi. The initial section shall have a 3-1/2 inch outside diameter collar welded to the lead end of the pipe to assist in reducing wall friction during driving of the pier to capacity. The Pier Sections that follow shall each have a Coupling welded to one end. Steel in this section shall conform to ASTM A513.
   2. Standard Pier Section (3-1/2" Diameter x 0.160" Wall Thickness): Each Pier Section shall be fabricated from a 3-1/2 inch outside diameter by 42-inch long mill rolled galvanized steel section with a 0.160 inch wall thickness. Yield strength shall be 50,000 psi and tensile strength shall be 55,000 psi. A triple coat corrosion protection of zinc chromate and clear polymer coating shall be provided. The initial section shall have a 4 inch outside diameter collar welded to the lead end of the pipe to assist in reducing wall friction during driving of the pier to capacity. The Pier Sections that follow shall each have a Coupling welded to one end. Steel in this section shall conform to ASTM A53, A513, A588, and B6.
   3. Pier Section (4" Diameter x 0.219" Wall Thickness): Each Pier Section shall be fabricated from a 4 inch outside diameter by 42-inch long mill rolled steel section with a 0.219 inch wall thickness. Yield strength shall be 50,000 psi and tensile strength shall be 55,000 psi. The initial section shall have a 4-1/2 inch outside diameter collar welded to the lead end of the pipe to assist in reducing wall friction during driving of the pier to capacity. The Pier Sections that follow shall each have a Coupling welded to one end. Steel in this section shall conform to ASTM A513.
   4. Heavy Duty Pier Section (4-1/2" Diameter x 0.238" Wall Thickness): Each Pier Section shall be fabricated from a 4-1/2 inch diameter, 0.238 wall thick pipe. Yield strength shall be 50,000 psi and tensile strength shall be 55,000 psi. The initial section shall have a 5 inch outside diameter

collar welded to the lead end of the pipe to assist in reducing wall friction during driving of the pier to capacity. The Pier Sections that follow shall each have a Coupling welded to one end. Steel in this section shall conform to ASTM A513.

F. Coupling: The Pier Coupling shall be a 6-inch long tubular steel section of suitable diameter to fit inside the Pier Section. The Coupling shall be inserted and attached 3 inches inside one end of each Pier Section that follows the initial Pier Section. The remaining 3 inches of the Coupling shall extend beyond the Pier Section. All components shall conform to ASTM A513. On the 3-1/2" Pier Pipe, the Coupling shall be attached by an embossed mechanical connection. On all other Pier Pipe sizes, the Coupling shall be attached by plug welding the Coupling to the Pier Pipe.

G. Modified Sleeve Pier Section (Modified Pier Only): The Modified Sleeve Pier Section shall be fabricated from a 3-1/2 inch diameter, 0.216 inch thick wall or 4 inch diameter, 0.219 inch thick wall mill rolled steel pipe, by 42 inches long. The yield strength shall be 50,000 psi. The Pipe Sleeve shall be mounted over the last Pier Section and shall be used to increase the moment transfer capacity from the Top Pier Platform to the Pier Section. Steel in this section shall conform to ASTM A36.

H. Pier Sleeving (Optional): Pier Sleeving shall be used to stiffen the segmented joints through areas of weak soils. Depending upon the product, the sleeve sections shall be fabricated from 3 inch diameter, schedule 40 pipe, or 4 inch diameter, 0.219 inch thick wall mill rolled steel pipe, or 4-1/2 inch diameter, 0.238 thick wall mill rolled steel pipe by 42 inches long. The Sleeving shall be driven over the Pier Sections in the area of weak soils. The Sleeving shall be installed in a manner that staggers the joints in the Pier with the joints in the Sleeving. Steel in this section shall conform to one or more of ASTM A53, A513, A588, B6.

I. Top Pier Platform
   1. Top Pier Platform For Standard, Modified And Plate Piers: The Standard Pier Platform shall be a welded assembly consisting of an 18 inch long steel tube of suitable size to fit over the Pier Section that shall form the cap cylinder. The cap cylinder shall have two 10 inch long by 5/8 inch thick steel plates welded as vertical stabilizers to the sides of the steel cap cylinder. The top of the Top Pier Platform shall be a 1 inch thick steel plate welded to the top of the cap cylinder. All steel elements shall conform to ASTM A36.
   2. Top Pier Platform For 4-1/2" Diameter Piers: A 4 inch outside diameter by 20 inch long steel pipe shall be welded to the inside of a 4-1/2 outside diameter by 10 inch long steel pipe to form the cap cylinder. The cap cylinder shall have two 9-1/2 inch long by 5/8 inch thick steel plates welded as vertical stabilizers to the sides of the steel cap cylinder. At the top of the Top Pier Platform shall be a 1 inch thick steel plate welded to the top of the cap cylinder. All steel elements shall conform to ASTM A36.

J. High Strength Pier Pins
   1. High Strength Pier Pins For Standard, Modified And Plate Piers: Two 5/8 inch diameter by three inch long high strength, heat treated cadmium plated Pier Pins are required per pier. The Pier Pins shall be capable of providing 55,000 pounds of ultimate shear resistance capacity in double shear configuration. Pier Pins shall be 10B21 Boron Steel and heat treated to RC36 +/-. Pins shall conform to ASTM A490.
   2. High Strength Pier Pins For 4-1/2" Diameter Piers: Two 3/4 inch diameter by 3-1/4 inch long high strength cadmium plated Pier Pins are required per pier. The Pier Pins are capable of providing a minimum 30,000 pounds of shear capacity at each point of shear. Pier Pins shall be equivalent to Grade 8.

K. Lift Shims: The Lift Shims shall be 5/8 inch by 1-1/2 inch and either 7 gauge or 16 gauge cadmium plated hot rolled steel. Lift Shims shall be used as required. The steel shall conform to ASTM A36.

L. Two Piece Lift Head Assembly: The Two Piece Lift Head shall be a welded assembly that consists of 5/8 inch thick and 1 inch thick steel plates and is capable of providing a minimum of 45,000 pounds resistance capacity. The Two Piece Lift Head Assembly shall be temporarily attached to the Pier

Bracket by means of one inch diameter by 2-3/4 inch long high strength locking pins that are inserted through matching 1-1/32 inch diameter holes.

M. Lateral Support Device: The Lateral Support Device is a specialized tool used to provide a horizontal force to the bottom of the Pier Bracket during Pier Section installation. The Lateral Support Device shall help counteract the torque developed between the structure and the Pier Bracket during Pier Section installation. The Lateral Support Device is a welded assembly of steel plate and tubing that has an adjustable length by means of a hand actuated thread and by a steel pin inserted through adjustment holes in the Lateral Support Device.

N. Helical Outrigger Assembly (Optional): The Helical Outrigger Assembly shall provide supplemental drive resistance when installing the Pier Sections. This optional assembly is for use on light structures with low structural integrity. It is also used to push the Pier Section through weak or unsuitable strata and to develop a higher factor of safety. The Helical Outrigger Assembly shall consist of Helical Anchors, Helical Extension Sections, Connector Pins and Extension Rods.

O. Weldments: All welded connections shall conform to the requirements of the American Welding Society, “Structural Welding Code AWS D1.1”, and applicable revisions.

1.3 EXECUTION

A. Exposure Of Footing Or Grade Beam: An area shall be excavated immediately adjacent to the building foundation to expose the footing, bottom of the grade beam, stem wall or column to a width of at least 36 inches and at least 15 inches beneath the proposed elevation of the base of the Pier Bracket. A chipping hammer shall be used to smooth and prepare the foundation for mounting of the Pier Bracket. The vertical and bottom face of the footing, if applicable, shall, to the extent possible, be smooth and at right angles to each other. The spread footing, if present, shall be notched to allow the Pier Bracket to mount directly under the bearing load of the stem wall, or shall be core drilled to allow the Pier Pipe from the Plate Pier to be installed. DO NOT cut any reinforcing steel in the footing element without approval by the engineer. The surfaces shall be smooth, free of all dirt, debris, and loose concrete so as to provide firm bearing surfaces for the Pier Bracket.

B. Installation Of The Pier Bracket
   1. Installation Of The Standard & Heavy Duty Two Piece Pier Bracket
      a. The Pier Bracket shall be temporarily mounted to the Drive Stand Assembly using one inch diameter locking pins and retaining clips. This assembly shall be lowered into the excavation adjacent to the foundation. The Pier Bracket shall then be seated flush against the footing using a hydraulic actuator or ram. The Pier Bracket shall be then fastened to the footing with two expansion Anchor Bolts. If the Pier Bracket does not have continuous bearing support on either the vertical or horizontal face, then Pressure Bearing Grout shall be used to provide proper bearing prior to driving the pier. Care should be exercised to insure that the Drive Stand Assembly frame is aligned plumb prior to driving each Pier Section. A carpenter’s level may be used to verify the vertical alignment.
      b. Install a Lateral Support Device between the bottom front side of the Pier Bracket and the vertical wall of the excavation opposite the pier. During installation of the Pier Sections, maintain support against the Pier Bracket with the Lateral Support Device. If required, install the optional Helical Outrigger Assembly to provide Supplemental Drive Resistance at this time.
   2. Installation Of The Two-Piece Plate Pier Bracket: A bolt template shall be used to properly locate and align the Pier Bracket at the location directed by the designer or directly over the cored hole in the footing element, if present. Once the anchor bolt holes are located, the 8 bolts shall be installed to the vertical face. The Plate Pier Bracket shall be installed with the nuts and washers provided with the anchor bolts. The longer bolts mount to the lower holes. Follow manufacturer’s recommendations for bolt installation and maintain maximum embedment of the bolts. If the Pier

Bracket does not have continuous bearing support on the vertical face, then Pressure Bearing Grout shall be used to provide proper bearing prior to driving the pier. Care should be exercised to insure that the Pier Bracket is aligned plumb. A carpenter's level may be used to verify the vertical alignment.

C. Driving And Testing Pier Sections

1. Driving Of Pier Sections: All Pier Sections shall be continuously driven by use of the Drive Stand Assembly. The initial Pier Section shall have the friction reduction collar on the bottom end. Additional Pier Sections shall be added as the pier driving operation continues. Driving of the Pier Sections will continue until rock or an equal bearing strata is reached.
2. Load Testing Pier Section
   a. Using The Double Acting Hydraulic Actuator: The pier shall be driven using the Drive Stand Assembly and the double acting hydraulic actuator until the maximum operating pressure of the hydraulic cylinder is reached or until lift of the structure is achieved, whichever occurs first. If the maximum hydraulic cylinder operating pressure is reached without lifting the structure, load test the Pier Section per Paragraph b following.
   b. Using A Hydraulic Ram: Load testing the Pier to a force greater than the capacity of the hydraulic cylinder shall be achieved by removing the double acting hydraulic actuator from the Drive Stand Assembly and replacing it with the Supplemental Block. Install a 25 or 50 ton hydraulic ram, depending upon test force required, between the last Pier Section and the Supplemental Block. The hydraulic ram shall be actuated with a hand pump until bearing strata is verified as defined by a maximum installation force of:
      45,000 lbs. for 2-7/8" Dia. x 0.165" 2-Piece Pier & Plate Pier,
      52,500 lbs. for 2-7/8" Dia. x 0.165" 2-Piece Modified Pier & Modified Plate Pier,
      65,000 lbs. for 3-1/2" Dia. x 0.160" 2-Piece Pier & Plate Pier,
      67,500 lbs. for 3-1/2" Dia. x 0.160" 2-Piece Modified Pier & Modified Plate Pier,
      71,250 lbs. for 4" Dia. x 0.219" 2-Piece Pier & Plate Pier
      75,000 lbs. for 4" Dia. x 0.219" 2-Piece Modified Pier & Modified Plate Pier
      82,500 lbs. for 4-1/2" Dia. Heavy Duty 2-Piece Pier;
      or until lift of the structure is achieved, whichever is less.
3. Drive Equipment Removal: The Drive Stand Assembly shall be then removed from the Pier Bracket by removing the one inch diameter locking pins. The optional Helical Outrigger Assembly shall be removed at this time. (NOTE: If the 3-1/2" Diameter Modified Pier is being installed, or if the Pier is to be sleeved; perform the operations in Paragraph 4. following, before removing the Drive Stand Assembly.)
4. Cutting Final Pier Section: It is likely that the final installed Pier Section will have to be removed from the hole and cut to a length suitable to provide space for installing the Top Pier Platform. Mark and cut the Pier Section to the proper length using a metal cutting saw capable of a smooth cut at 90 degrees to the length of the Pier Section. After cutting to length, the final Pier Section is replaced.

D. Driving Of Pipe Sleeve (Optional): Once the capacity of the pier is achieved, the Drive Stand Assembly shall be used to push the Modified Sleeving Pier Section or plain Pier Sleeving over the last Pier Section or sections. **Do not exceed the manufacturer's rated operating capacity for the hydraulic cylinde**r. The joints between the Pier Sleeves shall be staggered with the Couplings on the Pier Sections. Once the Pipe Sleeve(s) are installed, the Drive Stand Assembly shall be removed from the Pier Bracket by removing the one inch diameter locking pins.

E. Installing Pipe Grout (Optional): Once the pier is installed to load bearing stratum and cut to the proper elevation, a neat cement flowable grout may be installed to the pier pipe. The grout will increase the moment of inertia (stiffness) and corrosion resistance of the pier. The grout shall be introduced to the bottom of the pier by means of a tube inserted into the pier pipe. As the grout is pumped into the pier pipe the tube shall be removed as the elevation of the grout increases. The process shall be executed carefully so that air is not entrained into the grout.

F. Installation Of The Top Pier Platform: The Top Pier Platform shall be installed over the last installed Pier Section. Align the vertical stabilizers within the channels on the legs of the Pier Bracket and tap the Top Pier Platform until it contacts the top of the final Pier Section. A small port shall be provided between the cap cylinder and the platform to verify contact.

G. Installation Of The Two Piece Lift Head Assembly: The Two Piece Lift Head Assembly shall be temporarily attached to the Pier Bracket by aligning the holes in each assembly. The one inch diameter locking pins and clips are used to align and hold the two pieces together.

H. Lifting And Holding: The lifting and holding operation is designed to raise the structure and to restore it to as close to the original elevation as the construction will allow. Normally this lift and hold operation is accomplished with several Pier placements simultaneously. Install one 25 or 30 ton hydraulic ram as required between the Two Piece Lift Head Assembly and the Top Pier Platform on each pier. Install 3-1/2 inch square pier shims or equal to reduce excess space between the ram and the Two Piece Lift Head Assembly. The rams shall be actuated simultaneously to raise the structure. Lifting shall continue until the structure is restored to its approximate original elevation or to design specifications. Once restored, install the cadmium plated Lift Shims above the vertical stabilizer plates of the Top Pier Platform. The 7 gauge shims shall always be used for this operation. The 16 gauge shims shall only be used for fine adjustments between the stack of shims and the bottom of the pier pin holes in the Pier Bracket. Install two High Strength Pier Pins into the holes in the Pier Bracket by tapping the High Strength Pier Pins into place. There must be a snug fit of the High Strength Pier Pins and the Lift Shims. The load is transferred to the Pier System by removing the pressure from the hydraulic rams. Remove the ram and then remove the one inch locking pins along with the Two Piece Lift Head Assembly from the Pier Bracket.

I. Documentation: The installer shall carefully monitor the driving force applied to the Pier Sections as the pier is installed. It is recommended that the driving force be recorded at 3-1/2 foot unless directed otherwise by the Engineer. The form of the data may be as directed by the customer or the Engineer. The Lifting Force, Lift, and Pier Depth shall also be recorded and presented in a tabular form. In addition, the installer shall know and have the desired terminal pressure that will create the desired driving force approved by the Engineer prior to beginning the pier installation.

J. Void Filling (Optional - Depends upon soil characteristics, structure, and amount of lift): After raising operations are complete, voids created between the foundation and underlying soil shall be filled using a low pressure injection of grout slurry. Injection shall be through holes through the foundation. The contractor shall inject the grout in such a manner as to completely fill the void without trapping pockets of air. When the operation is complete, the contractor shall repair the injection holes by filling the holes with high strength non-shrinking grout and finishing to reasonably match the existing surface textures and elevations.

K. Clean Up: Once all of the equipment has been removed, the area shall be backfilled using the previously excavated soil. The backfill shall be made by placing no more than 8 inches of loose material in a lift and compacting that soil prior to placement of the next 8-inch lift. Sufficient lifts shall be used to restore the ground to its original elevation and density. Slope the soil contour for drainage away from the foundation.

END OF SECTION 31 66 15 00

SECTION 32 01 11 53 - TRAFFIC COATINGS

1.1 GENERAL

A. Description Of Work:
1. This specification covers the furnishing and installation of materials for traffic coating. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes traffic coatings for the following applications:
   a. Interior and exterior pedestrian traffic.
   b. Vehicular traffic.
   c. Pavement markings.

C. Submittals
1. Product Data: For each product indicated.
2. Shop Drawings: Show extent of each traffic coating. Include details for treating substrate joints and cracks, flashings, deck penetrations, and other termination conditions.
3. Samples: For each type of finish indicated.
4. Material test reports.
5. Material certificates.
6. Qualification data.
7. Maintenance data.
8. Warranty.
9. LEED Submittal:
   a. Product Data for Credit EQ 4.2: For interior field-applied traffic coatings and pavement marking paints, including printed statement of VOC content.

D. Quality Assurance
1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of traffic coatings required for this Project.
2. Fire-Test-Response Characteristics: Provide traffic coating materials with the fire-test-response characteristics as determined by testing identical products per test method below for deck type and slopes indicated by an independent testing and inspecting agency that is acceptable to authorities having jurisdiction.
   a. Class A **OR** B **OR** C, **as directed**, roof covering per ASTM E 108 or UL 790.
3. Preinstallation Conference: Conduct conference at Project site.

E. Delivery, Storage, And Handling
1. Deliver materials in original packages and containers with seals unbroken and bearing manufacturer's labels showing the following information:
   a. Manufacturer's brand name.
   b. Type of material.
   c. Directions for storage.
   d. Date of manufacture and shelf life.
   e. Lot or batch number.
   f. Mixing and application instructions.
   g. Color.
2. Store materials in a clean, dry location protected from exposure to direct sunlight. In storage areas, maintain environmental conditions within range recommended in writing by manufacturer.

F. Project Conditions

1. Environmental Limitations: Apply traffic coatings within the range of ambient and substrate temperatures recommended in writing by manufacturer. Do not apply traffic coatings to damp or wet substrates, when temperatures are below 40 deg F (5 deg C), when relative humidity exceeds 85 percent, or when temperatures are less than 5 deg F (3 deg C) above dew point.
   a. Do not apply traffic coatings in snow, rain, fog, or mist, or when such weather conditions are imminent during the application and curing period. Apply only when frost-free conditions occur throughout the depth of substrate.
2. Do not install traffic coating until items that will penetrate membrane have been installed.

G. Warranty
1. Special Warranty: Manufacturer's standard form in which traffic coating manufacturer agrees to repair or replace traffic coatings that deteriorate during the specified warranty period. Warranty does not include deterioration or failure of traffic coating due to unusual weather phenomena, failure of prepared and treated substrate, formation of new substrate cracks exceeding 1/16 inch (1.6 mm) in width, fire, vandalism, or abuse by snowplow, maintenance equipment, and truck traffic.
   a. Deterioration of traffic coatings includes the following:
      1) Adhesive or cohesive failures.
      2) Abrasion or tearing failures.
      3) Surface crazing or spalling.
      4) Intrusion of water, oils, gasoline, grease, salt, deicer chemicals, or acids into deck substrate.
   b. Warranty Period: Five years from date of Final Completion.

1.2 PRODUCTS

A. Materials
1. Traffic Coatings: Complying with ASTM C 957.
2. Material Compatibility: Provide primers; base, intermediate, and topcoats; and miscellaneous materials that are compatible with one another and with substrate under conditions of service and application, as demonstrated by manufacturer based on testing and field experience.
3. VOC Content: Provide traffic coatings and pavement marking paints, for use inside the weatherproofing system, with VOC content of 150 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Traffic Coating
1. Primer: Manufacturer's standard factory-formulated primer recommended for substrate and conditions indicated.
   a. Material: Epoxy **OR** Urethane, **as directed**.
2. Preparatory and Base Coats: Single- or multicomponent, aromatic liquid urethane elastomer.
3. Intermediate Coat: Single- or multicomponent, aromatic liquid urethane elastomer **OR** Single- or multicomponent, aliphatic liquid urethane elastomer **OR** Liquid epoxy, **as directed**.
4. Topcoat: Single- or multicomponent, aromatic liquid urethane elastomer **OR** Single- or multicomponent, aliphatic liquid urethane elastomer **OR** Single- or multicomponent, aromatic liquid urethane elastomer with UV inhibitors **OR** Liquid epoxy, **as directed**.
   a. Color: As selected by the Owner from manufacturer's full range.
5. Aggregate: Uniformly graded, washed silicon carbide sand **OR** Uniformly graded, washed silica sand **OR** Uniformly graded, washed flint shot silica **OR** Walnut shell granules **OR** Aluminum-oxide grit, **as directed**, of particle sizes, shape, and minimum hardness recommended in writing by traffic coating manufacturer.
   a. Spreading Rate: As recommended by manufacturer for substrate and service conditions indicated, but not less than the following:
      1) Intermediate Coat: 8 to 10 lb/100 sq. ft. (3.6 to 4.5 kg/10 sq. m) **OR** To refusal, **as directed**.

2) Topcoat: 8 to 10 lb/100 sq. ft. (3.6 to 4.5 kg/10 sq. m) **OR** As required to achieve slip-resistant finish, **as directed**.

C. Miscellaneous Materials
1. Joint Sealants: As specified in Division 07 Section "Joint Sealants".
2. Sheet Flashing: Nonstaining.
a. Minimum Thickness: 60 mils (1.5 mm) **OR** 50 mils (1.3 mm), **as directed**.
b. Material: Sheet material recommended in writing by traffic coating manufacturer **OR** Uncured neoprene sheet **OR** Cured neoprene sheet, **as directed**.
3. Adhesive: Contact adhesive recommended in writing by traffic coating manufacturer.
4. Reinforcing Strip: Fiberglass mesh recommended in writing by traffic coating manufacturer.

D. Pavement Markings
1. Pavement-Marking Paint: Alkyd-resin ready mixed, complying with AASHTO M 248, Type S **OR** N **OR** F, **as directed**.
a. Color: White **OR** Yellow **OR** As indicated, **as directed**.
1) Use blue for spaces accessible to people with disabilities.
2. Pavement-Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, with drying time of less than three **OR** 45, **as directed**, minutes.
a. Color: White **OR** Yellow **OR** As indicated, **as directed**.
1) Use blue for spaces accessible to people with disabilities.
3. Glass Beads: AASHTO M 247, Type 1.

1.3 EXECUTION

A. Examination
1. Examine substrates, with Installer present, for compliance with requirements and for other conditions affecting performance of traffic coatings.
a. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance.
b. Verify compatibility with and suitability of substrates.
c. Begin coating application only after minimum concrete curing and drying period recommended by traffic coating manufacturer has passed, after unsatisfactory conditions have been corrected, and after surfaces are dry.
d. Verify that substrates are visibly dry and free of moisture.
1) Test for moisture vapor transmission by plastic sheet method according to ASTM D 4263.
2) Test for moisture content by measuring with an electronic moisture meter **OR** method recommended in writing by manufacturer, **as directed**.
e. Application of coating indicates acceptance of surfaces and conditions.

B. Preparation
1. Clean and prepare substrates according to ASTM C 1127 and manufacturer's written recommendations to produce clean, dust-free, dry substrate for traffic coating application.
2. Mask adjoining surfaces not receiving traffic coatings, deck drains, and other deck substrate penetrations to prevent spillage, leaking, and migration of coatings.
3. Concrete Substrates: Mechanically abrade concrete surfaces to a uniform profile according to ASTM D 4259. Do not acid etch.
a. Remove grease, oil, paints, and other penetrating contaminants from concrete.
b. Remove concrete fins, ridges, and other projections.
c. Remove laitance, glaze, efflorescence, curing compounds, concrete hardeners, form-release agents, and other incompatible materials that might affect coating adhesion.
d. Remove remaining loose material to provide a sound surface, and clean surfaces according to ASTM D 4258.

C. Terminations And Penetrations
1. Prepare vertical and horizontal surfaces at terminations and penetrations through traffic coatings and at expansion joints, drains, and sleeves according to ASTM C 1127 and manufacturer's written recommendations.
2. Provide sealant cants at penetrations and at reinforced and nonreinforced, deck-to-wall butt joints.
3. Terminate edges of deck-to-deck expansion joints with preparatory base-coat strip.
4. Install sheet flashings at deck-to-wall expansion and dynamic joints, and bond to deck and wall substrates according to manufacturer's written recommendations.

D. Joint And Crack Treatment
1. Prepare, treat, rout, and fill joints and cracks in substrates according to ASTM C 1127 and manufacturer's written recommendations. Before coating surfaces, remove dust and dirt from joints and cracks according to ASTM D 4258.
   a. Comply with recommendations in ASTM C 1193 for joint-sealant installation.

E. Traffic Coating Application
1. Apply traffic coating material according to ASTM C 1127 and manufacturer's written recommendations.
   a. Start traffic coating application in presence of manufacturer's technical representative.
   b. Verify that wet film thickness of each component coat complies with requirements every 100 sq. ft. (9 sq. m).
2. Apply traffic coatings to prepared wall terminations and vertical surfaces to height indicated, and omit aggregate on vertical surfaces.
3. Cure traffic coatings according to manufacturer's written recommendations. Prevent contamination and damage during application and curing stages.

F. Pavement Markings
1. Do not apply traffic paint for striping and other markings until traffic coating has cured according to manufacturer's written recommendations.
2. Apply traffic paint for striping and other markings with mechanical equipment to produce uniform straight edges. Apply at manufacturer's recommended rates for a 15-mil- (0.38-mm-) minimum wet film thickness.
3. Spread glass beads uniformly into wet traffic paint at a rate of 6 lb/gal. (0.72 kg/L).

G. Field Quality Control
1. Testing: Engage a qualified testing agency to perform the following field tests and inspections and prepare test reports:
   a. Samples of material delivered to Project site shall be taken, identified, sealed, and certified in presence of the Owner and Contractor.
   b. Testing agency shall perform tests for characteristics specified, using applicable referenced testing procedures.
   c. Testing agency shall verify thickness of coatings during traffic coating application.
   d. If test results show traffic coating materials do not comply with requirements, remove noncomplying materials, prepare surfaces, and reapply traffic coatings.
2. Flood Testing: Flood test each deck area for leaks, according to recommendations in ASTM D 5957, after traffic coating has completely cured. Install temporary containment assemblies, plug or dam drains, and flood with potable water.
   a. Flood to an average depth of 2-1/2 inches (65 mm) with a minimum depth of 1 inch (25 mm) and not exceeding a depth of 4 inches (100 mm).
   b. Flood each area for 24 **OR** 48 **OR** 72, **as directed**, hours.
   c. After flood testing, repair leaks, repeat flood tests, and make further repairs until traffic coating installation is watertight.
   d. Engage an independent testing agency to observe flood testing and examine underside of decks and terminations for evidence of leaks during flood testing.

3. Final Traffic Coating Inspection: Arrange for traffic coating manufacturer's technical personnel to inspect membrane installation on completion.
   a. Notify the Owner 48 hours in advance of date and time of inspection.
4. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

H. Protecting And Cleaning
1. Protect traffic coatings from damage and wear during remainder of construction period.
2. Clean spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

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Task	Specification	Specification Description
32 01 11 53	03 31 13 00	Cement Concrete Pavement

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SECTION 32 01 13 61 - ASPHALT PAVING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for asphalt paving. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Cold milling of existing hot-mix asphalt pavement.
b. Hot-mix asphalt patching.
c. Hot-mix asphalt paving.
d. Hot-mix asphalt paving overlay.
e. Asphalt surface treatments.
f. Pavement-marking paint.
g. Traffic-calming devices.
h. Imprinted asphalt.

C. Definition
1. Hot-Mix Asphalt Paving Terminology: Refer to ASTM D 8 for definitions of terms.

D. Submittals
1. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.
a. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.
b. Job-Mix Designs: For each job mix proposed for the Work.
2. Material Certificates: For each paving material, from manufacturer.

E. Quality Assurance
1. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by authorities having jurisdiction or the DOT of state in which Project is located.
2. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of State or local DOT for asphalt paving work.
a. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.
3. Preinstallation Conference: Conduct conference at Project site.

F. Delivery, Storage, And Handling
1. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.
2. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.

G. Project Conditions
1. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:
a. Prime Coat: Minimum surface temperature of 60 deg F (15.6 deg C).
b. Tack Coat: Minimum surface temperature of 60 deg F (15.6 deg C).

c. Slurry Coat: Comply with weather limitations in ASTM D 3910.
d. Asphalt Base Course: Minimum surface temperature of 40 deg F (4.4 deg C) and rising at time of placement.
e. Asphalt Surface Course: Minimum surface temperature of 60 deg F (15.6 deg C) at time of placement.

2. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 deg F (4.4 deg C) for oil-based materials **OR** 55 deg F (12.8 deg C) for water-based materials, **as directed**, and not exceeding 95 deg F (35 deg C).
3. Imprinted Asphalt Paving: Proceed with coating imprinted pavement only when air temperature is at least 50 deg F (10 deg C) and rising and will not drop below 50 deg F (10 deg C) within 8 hours of coating application. Proceed only if no precipitation is expected within two hours after applying the final layer of coating.

1.2 PRODUCTS

A. Aggregates
1. General: Use materials and gradations that have performed satisfactorily in previous installations.
2. Coarse Aggregate: ASTM D 692, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.
3. Fine Aggregate: ASTM D 1073 or AASHTO M 29, sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.
a. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.
4. Mineral Filler: ASTM D 242 or AASHTO M 17, rock or slag dust, hydraulic cement, or other inert material.

B. Asphalt Materials
1. Asphalt Binder: AASHTO M 320 or AASHTO MP 1a, PG 64-22 **OR** PG 58-28 **OR** PG 70-22, **as directed**.
2. Asphalt Cement: ASTM D 3381 for viscosity-graded material **OR** ASTM D 946 for penetration-graded material, **as directed**.
3. Prime Coat:
a. ASTM D 2027, medium-curing cutback asphalt, MC-30 or MC-70 **OR** MC-250, **as directed**.
OR
Asphalt emulsion prime coat complying with State or local DOT requirements.
4. Tack Coat: ASTM D 977 or AASHTO M 140 emulsified asphalt, or ASTM D 2397 or AASHTO M 208 cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.
5. Fog Seal: ASTM D 977 or AASHTO M 140 emulsified asphalt, or ASTM D 2397 or AASHTO M 208 cationic emulsified asphalt, slow setting, factory diluted in water, of suitable grade and consistency for application.
6. Slurry Seal: ASTM D 3910, Type 1 **OR** Type 2 **OR** Type 3, **as directed.**
7. Chip Seal: ASTM D 977 or AASHTO M 140 emulsified asphalt, or ASTM D 2397 or AASHTO M 208 cationic emulsified asphalt, slow setting, factory diluted in water, of suitable grade and consistency for application. RS-2 **OR** RS-2P **OR** CRS-2 **OR** CRS-2P **OR** HFRS-2 **OR** HFRS-**2P**, **as directed.**
8. Sand Seal: AASHTO M 140 emulsified asphalt or AASHTO M 208 cationic emulsified asphalt, slow setting, factory diluted in water, of suitable grade and consistency for application. Sand shall meet the following gradation as tested by AASHTO T27.
9. Water: Potable.
10. Undersealing Asphalt: ASTM D 3141, pumping consistency.

C. Auxiliary Materials
1. Herbicide: Commercial chemical for weed control, registered by the EPA. Provide in granular, liquid, or wettable powder form.
2. Sand: ASTM D 1073 or AASHTO M 29, Grade Nos. 2 or 3.
3. Paving Geotextile: AASHTO M 288, nonwoven polypropylene; resistant to chemical attack, rot, and mildew; and specifically designed for paving applications.
4. Joint Sealant: ASTM D 6690 or AASHTO M 324, Type I **OR** Type II or III **OR** Type IV, **as directed**, hot-applied, single-component, polymer-modified bituminous sealant.
5. Pavement-Marking Paint: Color shall be White **OR** Yellow **OR** Blue, **as directed**.
   a. Alkyd-resin type, lead and chromate free, ready mixed, complying with AASHTO M 248, Type N **OR** Type F **OR** Type S, **as directed**; colors complying with FS TT-P-1952.
   OR
   MPI #32 Alkyd Traffic Marking Paint.
   OR
   Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, Type II, with drying time of less than three **OR** 45, **as directed**, minutes.
   OR
   MPI #97 Latex Traffic Marking Paint.
6. Glass Beads: AASHTO M 247, Type 1.
7. Wheel Stops:
   a. Precast, air-entrained concrete, 2500-psi (17.2-MPa) minimum compressive strength, 4-1/2 inches (115 mm) high by 9 inches (225 mm) wide by 72 inches (1800 mm) long. Provide chamfered corners, drainage slots on underside, and holes for anchoring to substrate.
   OR
   Solid, integrally colored, 96 percent recycled HDPE or commingled postconsumer and postindustrial recycled plastic; UV stabilized; 4 inches (100 mm) high by 6 inches (150 mm) wide by 72 inches (1800 mm) long. Provide chamfered corners, drainage slots on underside, and holes for anchoring to substrate.
   b. Dowels: Galvanized steel, 3/4-inch (19-mm) diameter, 10-inch (254-mm) minimum length.
   c. Adhesive: As recommended by wheel-stop manufacturer for application to asphalt pavement.

D. Preformed Traffic-Calming Devices
1. Speed Bumps **OR** Humps **OR** Cushions, **as directed**: Solid, integrally colored, 100 percent postconsumer or commingled postconsumer and postindustrial recycled rubber **OR** plastic, **as directed**; UV stabilized. Provide holes for anchoring to substrate.
   a. Size: Modular bumps 2 inches (51 mm) high by 10 inches (254 mm) wide by 72 inches (1800 mm) long, with overall length as dimensioned on Drawings.
   b. Size: Modular assemblies 3 inches (76 mm) high by 12 feet (3.7 m) in overall width **OR** 4 inches (102 mm) high by 14 feet (4.3 m) in overall width, **as directed**, with overall length as dimensioned on Drawings.
   c. Mounting Hardware: Galvanized-steel spike, 1/2-inch (13-mm) diameter, 10-inch (254-mm) minimum length **OR** lag screw, shield, and washers; 1/2-inch (13-mm) diameter, 8-inch (203-mm) minimum length **OR** hardware as standard with device manufacturer, **as directed**.
   d. Adhesive: As recommended by device manufacturer.

E. Imprinted Asphalt Materials
1. Templates: Imprinted-asphalt manufacturer's standard flexible templates for imprinting pattern into hot asphalt paving.
   a. Pattern: Running bond brick **OR** Cobblestone **OR** Custom pattern indicated on Drawings, **as directed**.
2. Coating System: Imprinted-asphalt manufacturer's standard system formulated for exterior application on asphalt paving surfaces.
   a. Base Coating: Portland cement and epoxy-modified acrylic polymer blended with sand and aggregate, formulated for exterior application on asphalt paving surfaces.

b. Top Coating: Epoxy-modified acrylic polymer blended with sand and aggregate, formulated for exterior application on asphalt paving surfaces.
c. Colorant: UV-stable pigment blend, added to each coating layer.
d. Color: White **OR** Yellow, **as directed**.

3. Precut Marking Material: Imprinted-asphalt manufacturer's standard, reflectorized, thermoplastic, 90-mil (2.3-mm) minimum thickness, formulated for exterior application on asphalt paving surfaces, and matching the imprinted pattern of templates.

F. Mixes

1. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes approved by authorities having jurisdiction; designed according to procedures in AI MS-2, "Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types"; and complying with the following requirements:
   a. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
   b. Base Course: In accordance with state or local DOT specifications.
   c. Surface Course: In accordance with state or local DOT specifications.
2. Hot-Mix Asphalt Based on ASTM D 3515 Requirements: Dense, hot-laid, hot-mix asphalt plant mixes approved by authorities having jurisdiction and designed according to procedures in AI MS-2, "Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types."
   a. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
   b. Provide mixes complying with composition, grading, and tolerance requirements in ASTM D 3515 for the following nominal, maximum aggregate sizes:
      1) Base Course: 1 inch (25 mm).
      2) Surface Course: 1/2 inch (13 mm).
3. Emulsified-Asphalt Slurry: ASTM D 3910, Type 1 **OR** Type 2 **OR** Type 3, **as directed**.

1.3 EXECUTION

A. Examination

1. Verify that subgrade is dry and in suitable condition to begin paving.
2. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
   a. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph (5 km/h).
   b. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons (13.6 tonnes).
   c. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by the Owner, and replace with compacted backfill or fill as directed.
3. Proceed with paving only after unsatisfactory conditions have been corrected.
4. Verify that utilities, traffic loop detectors, and other items requiring a cut and installation beneath the asphalt surface have been completed and that asphalt surface has been repaired flush with adjacent asphalt prior to beginning installation of imprinted asphalt.

B. Cold Milling

1. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.
   a. Mill to a depth of 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**.
   b. Mill to a uniform finished surface free of excessive gouges, grooves, and ridges.
   c. Control rate of milling to prevent tearing of existing asphalt course.
   d. Repair or replace curbs, manholes, and other construction damaged during cold milling.

e. Excavate and trim unbound-aggregate base course, if encountered, and keep material separate from milled hot-mix asphalt.
f. Transport milled hot-mix asphalt to asphalt recycling facility.
g. Keep milled pavement surface free of loose material and dust.

C. Patching
1. Hot-Mix Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches (300 mm) into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.
2. Portland Cement Concrete Pavement: Break cracked slabs and roll as required to reseat concrete pieces firmly.
   a. Pump hot undersealing asphalt under rocking slab until slab is stabilized or, if necessary, crack slab into pieces and roll to reseat pieces firmly.
   b. Remove disintegrated or badly cracked pavement. Excavate rectangular or trapezoidal patches, extending into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Recompact existing unbound-aggregate base course to form new subgrade.
3. Tack Coat: Apply uniformly to vertical surfaces abutting or projecting into new, hot-mix asphalt paving at a rate of 0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m).
   a. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
   b. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.
4. Patching:
   a. Fill excavated pavements with hot-mix asphalt base mix for full thickness of patch and, while still hot, compact flush with adjacent surface.
      OR
      Partially fill excavated pavements with hot-mix asphalt base mix and, while still hot, compact. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.

D. Repairs
1. Leveling Course: Install and compact leveling course consisting of hot-mix asphalt surface course to level sags and fill depressions deeper than 1 inch (25 mm) in existing pavements.
   a. Install leveling wedges in compacted lifts not exceeding 3 inches (75 mm) thick.
2. Crack and Joint Filling: Remove existing joint filler material from cracks or joints to a depth of 1/4 inch (6 mm).
   a. Clean cracks and joints in existing hot-mix asphalt pavement.
   b. Use emulsified-asphalt slurry to seal cracks and joints less than 1/4 inch (6 mm) wide. Fill flush with surface of existing pavement and remove excess.
   c. Use hot-applied joint sealant to seal cracks and joints more than 1/4 inch (6 mm) wide. Fill flush with surface of existing pavement and remove excess.

E. Surface Preparation
1. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.
2. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.
   a. Mix herbicide with prime coat if formulated by manufacturer for that purpose.
3. Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of 0.15 to 0.50 gal./sq. yd. (0.7 to 2.3 L/sq. m). Apply enough material to penetrate and seal but not flood surface. Allow prime coat to cure.
   a. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.

b. Protect primed substrate from damage until ready to receive paving.

4. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m).
   a. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
   b. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

F. Paving Geotextile Installation
1. Apply tack coat **OR** asphalt binder **OR** asphalt cement, **as directed**, uniformly to existing pavement surfaces at a rate of 0.20 to 0.30 gal./sq. yd. (0.8 to 1.2 L/sq. m).
2. Place paving geotextile promptly according to manufacturer's written instructions. Broom or roll geotextile smooth and free of wrinkles and folds. Overlap longitudinal joints 4 inches (100 mm) and transverse joints 6 inches (150 mm).
   a. Protect paving geotextile from traffic and other damage and place hot-mix asphalt paving overlay the same day.

G. Hot-Mix Asphalt Placing
1. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
   a. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
   b. Place hot-mix asphalt surface course in single lift.
   c. Spread mix at minimum temperature of 250 deg F (121 deg C).
   d. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
   e. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.
2. Place paving in consecutive strips not less than 10 feet (3 m) wide unless infill edge strips of a lesser width are required.
   a. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Complete a section of asphalt base course before placing asphalt surface course.
3. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

H. Joints
1. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.
   a. Clean contact surfaces and apply tack coat to joints.
   b. Offset longitudinal joints, in successive courses, a minimum of 6 inches (150 mm).
   c. Offset transverse joints, in successive courses, a minimum of 24 inches (600 mm).
   d. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations" **OR** as shown on Drawings, **as directed**.
   e. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
   f. Compact asphalt at joints to a density within 2 percent of specified course density.

I. Compaction
1. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

a. Complete compaction before mix temperature cools to 185 deg F (85 deg C).

2. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.
3. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:
   a. Average Density:
      1) 96 percent of reference laboratory density according to ASTM D 6927 or AASHTO T 245, but not less than 94 percent nor greater than 100 percent.
      OR
      92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent nor greater than 96 percent.
4. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.
5. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.
6. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.
7. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.
8. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

J. Asphalt Curbs
1. Construct hot-mix asphalt curbs over compacted pavement surfaces. Apply a light tack coat unless pavement surface is still tacky and free from dust. Spread mix at minimum temperature of 250 deg F (121 deg C).
   a. Asphalt Mix: Same as pavement surface-course mix.
2. Place hot-mix asphalt to curb cross section indicated or, if not indicated, to local standard shapes, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after hot-mix asphalt has cooled.

K. Asphalt Traffic-Calming Devices
1. Construct hot-mix asphalt speed bumps, humps, cushions, and tables over compacted pavement surfaces. Apply a tack coat unless pavement surface is still tacky and free from dust. Spread mix at minimum temperature of 250 deg F (121 deg C).
   a. Tack Coat Application: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m).
   b. Asphalt Mix: Same as pavement surface-course mix.
   c. Before installation, mill pavement that will be in contact with bottom of traffic-calming device. Mill to a depth of 1 inch (25 mm) from top of pavement to a clean, rough profile.
2. Place hot-mix asphalt to cross section indicated, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after hot-mix asphalt has cooled.

L. Installation Tolerances
1. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:
   a. Base Course: Plus or minus 1/2 inch (13 mm).
   b. Surface Course: Plus 1/4 inch (6 mm), no minus.
2. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot (3-m) straightedge applied transversely or longitudinally to paved areas:
   a. Base Course: 1/4 inch (6 mm).

b. Surface Course: 1/8 inch (3 mm).
c. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch (6 mm).

3. Traffic-Calming Devices: Compact and form asphalt to produce the contour indicated and within a tolerance of plus or minus 1/8 inch (3 mm) of height indicated above pavement surface.

M. Surface Treatments
1. Fog Seals: Apply fog seal at a rate of 0.10 to 0.15 gal./sq. yd. (0.45 to 0.7 L/sq. m) to existing asphalt pavement and allow to cure. With fine sand, lightly dust areas receiving excess fog seal.
2. Slurry Seals: Apply slurry coat in a uniform thickness according to ASTM D 3910 and allow to cure.
a. Roll slurry seal to remove ridges and provide a uniform, smooth surface.
3. Chip Seals: Apply asphalt binder directly to the pavement followed by a layer of ¼ inch aggregate chips **OR** as directed, and roll to embed aggregate into the binder.
a. Can be applied as double **OR** triple layers, **as directed,** which are accomplished by applying additional layers of asphaltic material and aggregate. After applying each layer of aggregate, the surface is compacted using a roller to embed aggregates in the binder.
4. Sand Seals: Spray emulsion directly to the pavement followed by a layer of sand. The sand can be spread immediately for maximum stick, **OR** wait until after the emulsion breaks and be rolled with a pneumatic tire roller, **as directed**.

N. Pavement Marking
1. Do not apply pavement-marking paint until layout, colors, and placement have been verified with the Owner.
2. Allow paving to age for 30 **OR** 90, **as directed**, days before starting pavement marking.
3. Sweep and clean surface to eliminate loose material and dust.
4. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils (0.4 mm).
a. Broadcast glass beads uniformly into wet pavement markings at a rate of 6 lb/gal. (0.72 kg/L).

O. Wheel Stops
1. Install wheel stops in bed of adhesive as recommended by manufacturer.
2. Securely attach wheel stops to pavement with not less than two galvanized-steel dowels embedded at one-quarter to one-third points. Securely install dowels into pavement and bond to wheel stop. Recess head of dowel beneath top of wheel stop.

P. Preformed Traffic-Calming Devices
1. Install preformed speed bumps **OR** humps **OR** cushions, **as directed**, in bed of adhesive as recommended by manufacturer for heavy traffic.
2. Securely attach preformed speed bumps **OR** humps **OR** cushions, **as directed**, to pavement with hardware spaced as recommended by manufacturer for heavy traffic. Recess head of hardware beneath top surface.

Q. Imprinting Asphalt
1. General: Imprint asphalt according to manufacturer's written instructions, using manufacturer's recommended equipment.
2. Freshly Laid Asphalt: Immediately after asphalt has been laid and compacted but still plastic, begin the surface imprinting process.
a. Monitor asphalt surface temperature in compliance with manufacturer's written recommendations to ensure required temperature to perform surface imprinting.
b. Reheat asphalt if surface temperature drops below that required.
3. Reheating Asphalt: Soften asphalt pavement surface by heating to a depth of at least 1/2 inch (13 mm) without burning asphalt.

a. Heat to a temperature of 300 to 325 deg F (149 to 163 deg C) immediately before applying templates.
b. Regularly monitor the pavement temperature to prevent overheating.
c. Direct flame heaters are not permitted.
d. If pavement is overheated and begins to emit black smoke, remove damaged pavement by milling down 1 inch (25 mm) and replace removed pavement with new, compacted surface course prior to resuming imprinting work.

4. Surface Imprinting: Apply and imprint templates to a minimum depth of 1/4 inch (6 mm) **OR** as required to embed precut marking material flush or barely beneath pavement surface, **as directed**.
5. Coating Application: After imprinted surface has cooled, apply two layers of base coating followed by two layers of top coating **OR** four layers of top coating, **as directed**. Do not allow traffic until coating has completely dried and cured.
6. Precut Marking Material Application: Position precut marking material aligned with imprinted pattern and slowly heat to a temperature no higher than 325 deg F (163 deg C) until marking material begins to liquefy and flow. Do not allow traffic until installed marking material has cooled to ambient temperature.

R. Field Quality Control
1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
2. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.
3. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.
4. Traffic-Calming Devices: Finished height of asphalt speed bumps, humps, cushions, and tables above pavement will be measured for compliance with tolerances.
5. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D 979 or AASHTO T 168.
   a. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.
   b. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
      1) One core sample will be taken for every 1000 sq. yd. (836 sq. m) or less of installed pavement, with no fewer than 3 cores taken.
      2) Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.
6. Replace and compact hot-mix asphalt where core tests were taken.
7. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

S. Disposal
1. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an EPA-approved landfill.
   a. Do not allow milled materials to accumulate on-site.

END OF SECTION 32 01 13 61

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SECTION 32 01 13 61a - CRACK SEALING OF BITUMINOUS PAVEMENTS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for crack sealing of bituminous pavements. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Manufacturer's Recommendations: Where installation procedures, or any part thereof, are required to be in accordance with the manufacturer's recommendations, printed copies of these recommendations shall be submitted to the Owner. Installation of the material will not be allowed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.
2. Schedules/Construction Equipment List: List of proposed equipment to be used in performance of construction work including descriptive data shall be submitted to the Owner.
3. Samples: Samples of the materials (sealant, primer if required, and backup material), in sufficient quantity for testing and approval shall be submitted to the Owner. No material will be allowed to be used until it has been approved.

C. Safety: Joint sealant shall not be placed within 25 feet of any liquid oxygen (LOX) equipment, LOX storage, or LOX piping. Joints in this area shall be thoroughly cleaned and left unsealed.

D. Test Requirements: The joint sealant and backup or separating material shall be tested for conformance with the referenced applicable material specification. Testing of the materials shall be performed in an approved independent laboratory and certified copies of the test reports shall be submitted and approved prior to the use of the materials at the job site. Samples will be retained by the Owner for possible future testing should the materials appear defective during or after application. Conformance with the requirements of the laboratory tests specified will not constitute final acceptance of the materials. Final acceptance will be based on the performance of the in-place materials.

E. Equipment: Machines, tools, and equipment used in the performance of the work required by this section shall be approved before the work is started and shall be maintained in satisfactory condition at all times.

1.2 PRODUCTS

A. Materials
1. Liquid Asphalt: ASTM D 2027, Grade MC-250.
2. Emulsified Asphalt: ASTM D 977, Grade AS-2.
3. Sealing Compound: ASTM D 3405.
4. Backer Rod: ASTM D 5249.
5. Fine Aggregate: Natural sand or crusher dust having a maximum size of not more than 1/8 inch and be free of clay or organic-matter.

1.3 EXECUTION

A. Preparation:
1. All cracks to be sealed shall be cleaned of dirt and debris, and moisture shall be removed.

2. Crack Cleaning Equipment shall consist of a portable air compressor with hose and nozzles for directing air directly into cracks and stiff bristle brooms.
3. Heating Equipment for Liquid Asphalt shall be mobile and shall be equipped with an agitating device for stirring material during heating, a thermometer, regulating equipment for heat control, and a gravity-type draw-off valve.
4. Heating Equipment for Sealing Compound: Unless otherwise required by the manufacturer's recommendations, the equipment shall be mobile and shall consist of double-boiler, agitator-type kettles with oil medium in the outer space for heat transfer. The applicator unit shall be so designed that the sealant will circulate through the delivery hose and return to the inner kettle when not sealing cracks.
5. Application Equipment shall have a spout or nozzle of such size that the sealing material will be placed in the cracks without entrapping air in cracks or spreading material on adjacent pavement surface.

B. Installation:
1. Backer Rod: Install backer in accordance with manufacturer's instructions where required under sealing compound.
2. Sealing Compound: All cracks 1/8 inch wide and wider shall be sealed. The application temperature for sealing compound shall comply with ASTM C 1193. Cracks 1/2 inch wide and wider shall be filled with a slurry of fine sand and an emulsified asphalt or liquid asphalt. After the slurry has cured, cracks shall be sealed with liquid asphalt or emulsified asphalt and lightly sanded.
3. Liquid and Emulsified Asphalt Sealer: The temperature shall be varied so that it flows freely into cracks and completely fills cracks without entrapping air. Cracks shall be free of moisture before filling and shall be filled slightly above the pavement surface. When excess sealer has been removed, the sealer shall be covered with fine sand.
4. Traffic Control: Traffic will not be permitted over sealed cracks until the sealer has cooled so that it is not picked up by vehicle tires. The Contractor will be responsible for all barricades and flagmen necessary to control traffic.

END OF SECTION 32 01 13 61a

SECTION 32 01 13 61b - SPRAY APPLICATIONS, SEAL COATS, AND SURFACE TREATMENTS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for the spray applications, seal coats, and surface treatments of asphalt concrete pavements. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Bituminous Material: Bituminous material shall be liquid asphalt complying with ASTM D 2028, Grade RC-25O, or tar complying with ASTM D 490, Grade RT-6.

B. Aggregate: Aggregates shall consist of crushed stone, crushed gravel, or crushed slag. The moisture content of the aggregate shall be such that the aggregate will be readily coated with the bituminous material. Aggregate gradations shall be in compliance with ASTM C 136.

C. Construction Equipment
1. Bituminous Distributor shall be designed and equipped to distribute the bituminous material uniformly at even heat on variable widths of surface at readily determined and controlled rates and pressures recommended by the manufacturer and with an allowable variation from any specified rate not exceeding 5 percent.
2. Single-Pass Surface Treatment Machine shall be capable of distributing the bituminous material and aggregates uniformly in controlled amounts in a single-pass operation over the surface to be sealed.
3. Heating Equipment for Storage Tanks shall consist of steam coils, hot oil coils, or electrical coils. If steam or hot oil coils are used, the coils must be so designed and maintained that the bituminous material cannot become contaminated.
4. Power Rollers shall be the self-propelled tandem and three-wheel type rollers, weighing not less than 5 tons and shall be suitable for rolling bituminous pavements.
5. Self-Propelled Pneumatic-Tired rollers shall have a total compacting width of not less than 60 inches. The gross weight shall be adjustable within the ranges of 200 to 350 lb/in. of compacting width.
6. Spreading Equipment: Aggregate spreading equipment shall be adjustable and capable of spreading aggregate at controlled amounts per square yard.
7. Drags: Broom drags shall consist of brooms mounted on a frame, designed to spread fine aggregate uniformly over the surface of a bituminous pavement. Towing equipment shall have pneumatic tires.
8. Brooms and Blowers shall be of the power type and shall be suitable for cleaning surfaces of bituminous pavements.

1.3 EXECUTION

A. Installation
1. Spreading Aggregate: Application of seal aggregate shall immediately follow the application of bituminous material, and in no case shall the time to application exceed 15 minutes.

2. Brooming and Rolling: Begin the rolling operations immediately following the application of cover aggregate. Rolling shall be accomplished with pneumatic-tired rollers; steel-wheeled rollers shall be used in a supplementary capacity only. All surplus aggregate shall be swept off the surface and removed not less than 26 hours or more than four days after rolling is completed.

END OF SECTION 32 01 13 61b

SECTION 32 01 16 71 - GRINDING/GROOVING PAVEMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of grinding/grooving pavement. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: For each type of product indicated.

1.2 PRODUCTS - Not Used

1.3 EXECUTION

A. Grinding: This covers grinding asphalt concrete or portland cement concrete pavement and roadway surfaces of structures as shown on the plans and as specified in these specifications and the special provisions
1. Grinding shall be performed with abrasive grinding equipment utilizing diamond cutting blades.
2. Existing portland cement concrete pavement not constructed as part of the project shall be ground as follows:
a. Grinding shall be performed so that the pavement surface on both sides of all transverse joints and cracks has essentially the same depth of texture and does not vary from a true plane enough to permit a 1.9 mm thick shim 75 mm wide to pass under a one-meter straightedge adjacent to either side of the joint or crack when the straightedge is laid on the pavement parallel to centerline with its midpoint at the joint or crack. After grinding has been completed, the pavement shall conform to the straightedge and profile requirements specified in paving specification, paragraph "Final Finishing," except that pavement on tangent alignment and on horizontal curves of any radius shall have a profile index of 19 mm or less per 0.1-km.
b. Abnormally depressed areas due to subsidence or other localized causes will be excluded from testing with the profilograph and 3.6-m±0.06-m straightedge. The accumulated total of the excluded areas shall not exceed 5 percent of the total area to be ground. Profilograph testing shall end 8 m prior to excluded areas and shall resume 8 m following the excluded areas.
3. Existing asphalt concrete pavement not constructed as part of the project shall be ground so that the finished surface shall not vary from a true plane enough to permit a 3-mm thick shim 75 mm wide to pass under a straightedge 3.6 m±0.06-m long when the straightedge is laid on the finished surface parallel with the centerline. The transverse slope of the finished surface shall be uniform to a degree such that a 6 mm thick shim 75 mm wide will not pass under a straightedge 3.6 m±0.06-m long when the straightedge is laid on the finished surface in a direction transverse to the centerline and extending from edge to edge of a 3.6-m traffic lane.
4. Ground areas on structures, approach slabs and the adjacent 15 m of approach pavement shall conform to the provisions for smoothness and concrete cover over reinforcing steel.
5. Ground surfaces shall not be smooth or polished and, except as otherwise specified, shall have a coefficient of friction of not less than 0.30.
6. Residue from grinding operations shall be picked up by means of a vacuum attachment to the grinding machine and shall not be allowed to flow across the pavement nor be left on the surface of the pavement. Residue from grinding portland cement concrete pavement shall be disposed of

as directed. Residue from grinding asphalt concrete shall be disposed of outside the highway right of way.

7. At the option of the Contractor, the residue from grinding portland cement concrete pavement may be disposed of as directed by the authorities having jurisdiction over the site. A copy of the approval shall be delivered to the Engineer before disposing of residue at the site.
8. The noise level created by the combined grinding operation shall not exceed 86 dBA at a distance of 15 m at right angles to the direction of travel.

B. Grooving: This work shall consist of grooving the surface of asphalt concrete or Portland cement concrete pavement and bridge decks as shown on the plans and as specified in these specifications and the special provisions

1. Grooved areas shall begin and end at lines normal to the pavement center line and shall be centered within the lane width. If new concrete pavement is grooved, the grooving in any lane shall cover the full lane width.
2. Grooving blades shall be 2.41 mm ± 0.13-mm wide and shall be spaced 19 mm on centers. The grooves shall be cut not less than 3 mm nor more than 7 mm deep. The grooves on bridge decks shall be cut not less than 3 mm nor more than 5 mm deep. Grooves over inductive loop detectors shall be cut not less than 2 mm nor more than 3 mm deep.
3. At the beginning of each work shift, all grooving machines shall be equipped with a full complement of grooving blades that are capable of cutting grooves of the specified width, depth and spacing.
4. If during the course of work a single grooving blade on any individual grooving machine becomes incapable of cutting a groove, work will be permitted to continue for the remainder of the work shift, and the Contractor will not be required to otherwise cut the groove omitted because of the failed blade. Should 2 or more grooving blades on any individual grooving machine become incapable of cutting grooves the Contractor shall either:
   a. Discontinue work with the affected grooving machine within 15 m of the location where more than one blade became incapable, in which event the Contractor will not be required to otherwise cut the grooves omitted because of the failed blades; **OR**
      Continue work with the affected grooving machine for the remainder of the work shift and by other means cut all grooves omitted, including grooves omitted because a single blade was incapable, by the affected grooving machine within that work shift. The omitted grooves shall be cut before any of the grooving work performed during the time the grooves were omitted will be accepted.
5. The actual grooved area of any selected 0.6-m by 30 m longitudinal area of pavement specified to be grooved shall be not less than 95 percent of the selected area. Grooves which are omitted as permitted for blades which become incapable will be measured as being actually grooved. No area will be measured until omitted grooves, which are required to be cut before the area is accepted, have been cut. Except as provided for omitted grooves due to an incapable blade, any area within the selected area not grooved shall be due only to irregularities in the pavement surface and for no other reason.
6. Residue from grooving operations shall be picked up by means of a vacuum attachment to the grooving machine and shall not be allowed to flow across the pavement nor be left on the surface of the pavement. Residue from grooving portland cement concrete pavement shall be disposed of as directed. Residue from grooving asphalt concrete shall be disposed of outside the highway right of way.
7. At the option of the Contractor, the residue from grooving portland cement concrete pavement may be disposed as directed by the authorities having jurisdiction over the site. A copy of the approval shall be delivered to the Engineer before disposing of residue at the site.
8. The noise level created by the combined grooving operation shall not exceed 86 dBA at a distance of 15 m at right angles to the direction of travel.

C. Highway or Street Grooving: AASHTO recommends the following groove specifications: 2.4 mm wide; depth of 3.2 to 4.8 mm, and a center-to-center spacing of 19.1 mm (0.75 inches) (7). The center 10-foot portion of a 12-foot lane is typically grooved, leaving a 1-foot strip ungrooved at the edge of each lane.

D. Boat Ramp Grooving: Grooves shall be non-skid V-grooves spaced 2 inches on center, 1/2-inch radius, 1/2-inch deep.

E. Runway Grooving
   1. General
      a. The grooving dimensions shall be as follows:
         1) Depth - One-quarter (1/4) inch ± one sixteenth (1/16) inch
         2) Width - One-quarter (1/4) inch ± one sixteenth (1/16) inch
         3) Center to center - One and one-half (1 1/2) inch ± one eight (1/8) inch
      b. Grooving shall not begin until new pavement has properly cooled/cured and permission is given.
      c. In no case shall final painted pavement markings be applied prior to grooving.
   2. The pavement must be grooved by approved diamond bladed saw-cutting equipment. Variations in the grooving contour will not be permitted without approval. All reasonable precautions shall be taken to avoid breaking or chipping the pavement surfaces between grooves. Excessive spalling of the grooved edges will not be permitted.
   3. The Contractor shall groove bituminous concrete and portland cement concrete pavements according to the following specifications (from FAA Advisory Circular 150/5320-12B, Section IV):
      a. The depth of 90 percent or more of the groove shall not be less than 1/4 inch.
      b. The grooves shall be continuous for the entire runway length and transverse (perpendicular) to the direction of aircraft landing and takeoff operations.
      c. The grooves shall be continued to the end of the runway where the concrete meets the asphalt.
      d. The grooves shall not vary more than 3 inches in alignment for 75 feet, allowing for realignment every 500 feet.
      e. Grooves shall not be closer than 3 inches or more than 9 inches from transverse joints in concrete pavements.
      f. Grooving through longitudinal or diagonal saw kerfs where lighting cables are installed shall be avoided. Grooves may be continued through longitudinal construction joints.
      g. Grooves shall be sawed no closer than 6 inches and no more than 18 inches from inpavement light fixtures.
   4. Cleanup is extremely important and should be continuous throughout the grooving operations. Accumulation of debris resulting from the grooving operations shall be cleaned from the grooves and removed from the pavement by air jets, high pressure water streams, or other approved methods, after each grooving operation at hourly intervals. The Contractor shall provide water for cleanup operations. The waste material shall not be flushed into the storm or sanitary sewer system. The waste material shall not be allowed to drain onto the shoulders or left on the runway surface in order to prevent foreign object damage.

END OF SECTION 32 01 16 71

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SECTION 32 01 16 74 - BITUMINOUS REJUVENATION

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of bituminous rejuvenation of airfield pavements, roads, streets, parking areas, and other general applications by the use of a chemical rejuvenator. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Rejuvenator: The asphalt rejuvenating agent shall be composed of a petroleum resin-oil base uniformly emulsified with water and shall conform to the following physical and chemical requirements:

B. Property Test Method Requirement

Viscosity, S.F. at 77 F, sec.	ASTM D 244	15-40
Residue, % (1)	ASTM D 244 (Mod.)	60-65(min.)
Sieve Test, %	ASTM D 244 (Mod.)	0.10 (max.)
Viscosity @ 140 F, centistokes (2)	ASTM D 2170	80-500
Flash Point, Cleveland Open Cup(COC), ºF (3)	ASTM D 92	350 (min.)

(1) ASTM D 244 Modified Evaporation Test for percent residue is made by heating 50 gm samples to 300ºF until foaming ceases; then cool immediately and calculate results.
(2) Viscosity on residue obtained from evaporation test.
(3) Flash point on residue from evaporation test.

C. Aggregate: Gradation of mineral aggregate shall meet the following requirements:

Sieve Percent by Designation	Weight Passing
No. 16	100
No. 30	40-75
No. 50	4-12
No. 100	0-5

1.3 EXECUTION

A. Bituminous Storage Tanks shall be capable of heating the bituminous material under effective and positive control at all times to the required temperature.

B. Bituminous Distributor shall be designed and equipped to spray the bituminous material in a uniform double to triple lap at the temperature recommended by the manufacturer, at variable widths, and at readily determined and controlled rates from 0.04 to 0.2 gallons per square yard, plus or minus 5 percent.

C. Brooms and Blowers shall be of the power type.

D. Preparation of Surface: Immediately before applying the rejuvenator, all loose material, dirt, clay, or other objectionable material shall be removed from the surface to be treated.

E. Application of Rejuvenator: The rejuvenator shall be uniformly applied over the surface at the approved rate with an allowable variation of plus or minus 20 percent. Materials shall be applied at the temperature recommended by the manufacturer.

F. Excess Rejuvenator Material: Approved mineral aggregate shall be provided by the Contractor and shall be spread in sufficient quantity to effectively blot up any excess rejuvenator material remaining on the treated pavement surface after 24 hours.

G. Insufficient Rejuvenator Material: When it is determined by the Owner that the actual application rate of the rejuvenator is more than 20 percent below the approved application rate, subsequent application(s) shall be made within 24 hours to ensure adequate penetration into the pavement surface.

END OF SECTION 32 01 16 74

SECTION 32 01 16 74a - COLD MIX RECYCLING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of cold mix recycling of existing paving and the addition of new materials. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Aggregates:
1. General: Aggregates shall consist of material obtained from milling, or removing and crushing the existing in situ material, and/or new aggregate material as needed.
2. Aggregate Quality and Gradation: Aggregate for bituminous mixture shall be of such size that the material can be spread with a paver to the desired thickness and compacted to meet the specified smoothness, grade, and density requirements. New aggregates shall be approved and be equal to or better than the reclaimed aggregate in quality. Maximum size of new aggregate shall not exceed one-half of the layer thickness and in no case shall the maximum aggregate size exceed 1 inch.

B. Bituminous Materials: Bituminous materials, if required, shall be an emulsified asphalt conforming to ASTM D 977 or ASTM D 2397, grade as required.

C. Job-Mix Formula: The Job-Mix Formula (JMF) for the recycled mixture will be furnished by the Contractor to the Owner. The formula will indicate a definite percentage of water and asphalt to be added to the mixture. The JMF will be allowed an asphalt content tolerance of 0.3 percent. The asphalt content may be adjusted by the Owner to improve paving mixture, without adjustment in contract unit price. When asphalt is added, the optimum asphalt content will be selected to provide the following properties when samples are compacted at 250 F with 75 blows of standard Marshall hammer on each side of the specimen.

Property	Requirement
Stability minimum, pounds	1,800
Flow maximum, 1/100-inch units	16
Voids in total mix, percent	3-5
Voids filled with bitumen, percent	70-80

The water content will be selected to provide maximum density when samples are prepared at the optimum asphalt content and compacted with 75 blows of Marshall hammer at ambient temperature. When no asphalt binder is added to the mixture, the water content will be selected by the Owner to provide maximum density.

1.3 EXECUTION

A. Preparation of Bituminous Mixtures: The required amount of bituminous material for each batch, or calibrated amount of continuous mixing, shall be introduced into the mixer. Aggregates, asphalt emulsion, and water shall be mixed for 35 seconds or longer, as necessary, to thoroughly coat all

particles with bituminous material. When longer mixing time is necessary, additional mixing time shall be determined by the Owner.

B. Conditioning of Existing Surface: Ruts or soft yielding spots that appear in the existing pavement areas and deviations of surface from requirements specified shall be corrected. An asphalt tack coat shall be applied to all contact surfaces in advance of the recycled overlayment. The asphalt tack shall be placed at an asphalt residue coverage rate of 0.05 gal/sq. yd.

C. Placing:
   1. Layer Thickness and Curing: Each layer of compacted mixture shall be no more than 2-1/2 inches in thickness; each layer of bituminous mixture shall be allowed to cure for at least 5 days before placing a succeeding layer.
   2. Compaction of Mixture: Bituminous mixtures shall be rolled until all roller marks are eliminated and a density of at least 86 percent of the theoretical maximum density has been obtained when tested in accordance with MIL-STD-620, Method 101 or ASTM D 2041. When bituminous material is not added to the cold recycled mixture, the material shall be compacted to 100 percent of density determined by MIL-STD-621, Method 100, compaction effort designation CE-55.
   3. Joints: Longitudinal joints shall be offset at least 1 foot from existing joints. Transverse joints shall be offset at least 2 feet from existing transverse joints.
   4. Surface Smoothness: After final rolling, the pavement surface shall not vary in excess of 1/8 inch from a straightedge laid on the surface.

END OF SECTION 32 01 16 74a

SECTION 32 01 16 74b - CENTRAL PLANT HOT-MIX RECYCLING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of central plant hot-mix recycling of existing asphalt concrete intermediate and wearing courses for airfields, heliports, and heavy-duty pavements. The specification also includes the addition of new materials, as required to meet project requirements. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Aggregates:
1. General: Aggregates shall consist of material obtained from milling, or removing and crushing the existing in-situ material, and/or new aggregate material as needed.
2. Aggregate Quality and Gradation: Aggregate for the bituminous mixture shall be such size that the material can be spread with a paver to the desired thickness and compacted to meet the specified smoothness, grade, and density requirements. New aggregates shall be approved and shall be equal to or better than the reclaimed aggregate in quality. Maximum size of new aggregate shall not exceed one-half of the layer thickness, and in no case shall the maximum aggregate size exceed one inch. Aggregate gradations shall be as prescribed by local usage, with the approval of the Owner. In order to meet pollution requirements and ensure the recycled mixture is satisfactory, the amount of reclaimed asphalt pavement shall not exceed 60 percent for drum mixers or 50 percent for batch plants.

B. Mineral Filler shall conform to ASTM D 242.

C. Bituminous Materials:
1. New Asphalt Cement: The appropriate types and grades of bituminous materials for the anticipated use and climactic environment shall be used. Requirements of ASTM D 946 shall be used to specify penetration-graded asphalt cement, or ASTM D 3381 for viscosity-graded asphalt cement.
2. Recycled Asphalt Cement: The penetration of asphalt cement recovered from the recycled mixture shall be in accordance with ASTM D 1856 and shall have a penetration between 50 and 70 percent of that specified for the particular region for new asphalt cement, measured in accordance with ASTM D 5.

D. Job-Mix Formula (JMF): The JMF for the recycled mixture will be furnished by the Contractor to the Owner. The formula will indicate the percentage of reclaimed asphalt pavement, the percentage of bitumen, and the temperature of the completed mixture when discharged from the mixer. The requirements for stability, flow, and voids are shown in the following tables for nonabsorptive and absorptive mixtures, respectively.
1. Nonabsorptive-Aggregate Mixture

	Wearing Property Course	Intermediate Course
Stability minimum, lbs	1,800	1,800
Flow maximum, 1/100-inch units	16	16

Voids total mix, percent	3-5	5-7
Voids filled with bitumen, percent	70-80	50-70

2. Absorptive-Aggregate Mixture

	Wearing Property Course	Intermediate Course
Stability minimum, lbs.	1,800	1,800
Flow maximum, 1/100-inch units	16	16
Voids total mix, percent	2-4	4-6
Voids filled with bitumen, percent	75-80	55-75

When the water-absorption value of the entire blend of aggregate does not exceed 2.5 percent, the aggregate is designated as nonabsorptive. When the water-absorption value exceeds 2.5 percent as determined by ASTM C 127 and ASTM C 128, the aggregate is designated as absorptive.

1.3 EXECUTION

A. Preparation of Bituminous Mixtures: Aggregates, reclaimed asphalt pavement, mineral filler, bitumen, and recycling agent shall be conveyed into the mixer in proportionate quantities required to meet the JMF. Particles larger than 2 inches shall be removed from the reclaimed asphalt pavement prior to being added to the mixer. Mixing time shall be as required to obtain a uniform coating of the aggregate with the bituminous material. Temperature of bitumen at time of mixing will be as required to meet project requirements. Temperature of aggregate and mineral filler in the mixer shall not exceed 325 F when bitumen is added.

B. Surface Preparation of Underlying Course: Prior to placing of intermediate or wearing course, the underlying course shall be cleaned of all foreign or objectionable matter. The surface of previously constructed base course shall be sprayed with a prime coat at an asphalt residue coverage rate of 0.25 gal/sq. yd. Contact surfaces of previously constructed pavement, curbs, manholes, and other structures shall be sprayed with a thin tack coat at an asphalt residue coverage rate of 0.05 gal/sq. yd.

C. Placing:
1. Layer Thickness and Curing: A required uncompacted thickness of intermediate course, 7 inches or less, may be spread and compacted in one layer. Where the required thickness of base is more than 7 inches, the mixture shall be spread and compacted in two or more layers. Each layer of compacted mixture for the surface course shall be no more than 2-1/2 inches in thickness. Each layer of bituminous mixture shall be allowed to cure for at least 5 days before placing a succeeding layer.
2. Compaction of Mixture: Rolling shall begin as soon after placing as the mixture will bear roller without undue displacement. After the Contractor is assured of meeting crown, grade, and smoothness requirements, rolling shall be continued until a mat density of 98 to 100.0 percent and a joint density of 96.5 to 100.0 percent of density is obtained. Places inaccessible to rollers shall be thoroughly compacted with hot hand tampers.
3. Joints: Longitudinal joints shall be offset at least 1 foot from existing joints. Transverse joints shall be offset at least 2 feet from existing transverse joints.
4. Surface Smoothness: After final rolling, the pavement surface shall not vary in excess of 1/8 inch from a straightedge laid on the surface.

END OF SECTION 32 01 16 74b

Task	Specification	Specification Description
32 01 16 74	32 01 13 61	Asphalt Paving
32 01 17 61	32 01 13 61	Asphalt Paving
32 01 17 61	32 01 13 61a	Crack Sealing Of Bituminous Pavements
32 01 17 61	32 01 13 61b	Spray Applications, Seal Coats, And Surface Treatments
32 01 26 71	32 01 16 71	Grinding/Grooving Pavement
32 01 90 13	31 13 13 00	Tree Protection And Trimming
32 01 90 19	01 22 16 00	No Specification Required
32 01 90 23	31 13 13 00	Tree Protection And Trimming
32 01 90 26	31 13 13 00	Tree Protection And Trimming
32 01 90 36	31 13 13 00	Tree Protection And Trimming
32 01 90 36	31 31 19 13	Soil Sterilization
32 01 90 39	31 13 13 00	Tree Protection And Trimming
32 01 90 43	31 13 13 00	Tree Protection And Trimming
32 01 90 46	31 13 13 00	Tree Protection And Trimming
32 01 90 53	31 13 13 00	Tree Protection And Trimming

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SECTION 32 11 16 16 - CRUSHED STONE PAVING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of crushed stone paving. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

1.2 PRODUCTS

A. Aggregates: Aggregates shall consist of crushed stone or slag, crushed gravel, angular sand, or other approved materials. Aggregates shall be durable, sound, and free from foreign material.
1. Coarse Aggregates, consisting of angular fragments of uniform density and quality, shall have a percentage of wear not to exceed 50 percent after 500 revolutions when tested in accordance with ASTM C131. The amount of flat and elongated particles (length to width greater than 3 to 1) shall not exceed 30 percent.
2. Crushed Gravel shall be manufactured from gravel particles with the following gradation:

100% passing	2" sieve
25 - 60% passing	1/4" sieve
5 - 40% passing	#40 sieve
0 - 10%	#200 sieve

3. Crushed Stone shall contain at least 50 percent by weight of crushed pieces having two or more freshly fractured faces for each range of sizes.
4. Slag shall be an air-cooled blast-furnace product having a dry weight of not less than 65 pcf.

B. Binder Material shall consist of screenings, angular sand, or other finely divided mineral matter processed or naturally combined with the coarse aggregate.

1.3 EXECUTION

A. Installation:
1. Mixing and Placing: Materials shall be mixed in such a manner as to obtain a uniform stabilized-aggregate material and a uniform optimum water content for compaction. Mixing and placing procedures shall produce true grades, minimize segregation and degradation, optimize water content, and ensure a satisfactory base course.
2. Compaction: Each layer of stabilized-aggregate paving shall be compacted. Water content shall be maintained at optimum. Areas inaccessible to the rollers shall be compacted, with mechanical tampers and shall be shaped and finished by hand methods.
3. Layer Thickness: No layer shall be in excess of 8 inches nor less than 3 inches in compacted thickness.
4. Proof Rolling: Materials in paving or underlying materials that produce unsatisfactory results by rolling shall be removed and replaced with satisfactory materials and recompacted.
5. Edges of Paving: Approved materials shall be placed along edges of stabilized-aggregate paving course in such quantities as will compact to thickness of the course being constructed, allowing at least a l-foot width of the shoulder to be rolled and compacted simultaneously with rolling and compacting of each layer of the paving course.
6. Finishing: Finished surface shall be of uniform grade and texture.
7. Thickness Control: Compacted thickness of the stabilized paving course shall be within 1/2 inch of the thickness required.

END OF SECTION 32 11 16 16

SECTION 32 11 16 16a - CRUSHED STONE

1.1 GENERAL

A. Description Of Work
1. The work under this section consists of furnishing, placing and compacting crushed stone where called for and as detailed, in conformance with lines, grades and typical as follows or as directed by the Owner.

1.2 PRODUCTS

A. Materials
1. Material shall consist of clean, coating free, durable, sharp angled fragments of crushed stone, crushed ledge rock, or blends thereof that conform to the specific requirements of the following table. Shale will not be acceptable.
2. Crushed Stone used in Absorption Beds shall be washed and free of fines.
3. Gradation: Crushed stone sizes shall meet the gradation requirements of Table 1-1.

TABLE 1-1 (1)GRADATION OF CRUSHED STONE

Size Desig-nation	4"	3"	2-1/2"	2"	1-1/2"	1"	1/2"	1/4"	1/8"	No.80 Sieve
Scree-ning (2)							100	90-100		
1B								100	90-100	0-15
1A							100	90-100	0-15	
1[ST]							100	0-15		
1						100	90-100	0-15		
2					100	90-100	0-15			
3A				100	90-100	0-15				
3			100	90-100	5-70	0-15				
4A		100	90-100		0-20					
4	100	90-100		0-15						
5	90-100	0-15								

a. Percentage by weight passing the following square openings.
b. Screenings shall include all of the fine material passing a 1/4-inch screen.
4. All crushing plants shall be fitted with tailing chutes so that no aggregate will reach the bins other than that which passes through the proper screens

B. Soundness: Material furnished under this item shall be substantially free of shale or other soft, poor durability particles. A visual inspection of particle composition by the Owner will generally be the basis

for acceptance. Where the State elects to test for this requirement, a Magnesium Sulfate Soundness Loss exceeding 35 percent will be cause for rejection.

C. Contamination: Contamination of the crushed stone with any deleterious material, such as silt, clay, mud, ice, snow or organic materials, through any cause whatsoever, shall be corrected by the Contractor by excavation and replacement of the material in the affected areas.

D. Sampling: Samples and certified gradations shall be furnished by the Contractor to the Owner and approval of these samples must be received prior to delivery or placement of the material.

1.3 EXECUTION

A. Compaction: All material shall be placed in uniform horizontal layers not exceeding 6-inches thickness before compaction. All portions of each layer shall be mechanically compacted to the satisfaction of the Owner. Compaction equipment shall be approved by the Owner.

END OF SECTION 32 11 16 16a

SECTION 32 11 16 16b - SELECT GRAVEL

1.1 GENERAL

A. Description Of Work
1. The work under this section consists of furnishing, placing and compacting select gravel where called for and as detailed, in conformance with lines, grades and typical sections as provided or directed by the Owner.

1.2 PRODUCTS

A. Materials
1. Material shall consist of clean, durable gravel or crushed stone free from coating.
2. Select Gravel used for stone paving shall be manufactured from crushed stone and contain no gravel.
3. Gradation of gravel or stone shall be as follows with percent passing calculated by weight:

Select Gravel	
Sieve	Percent Passing
2"	100
1/4"	30 - 65
No. 40	5 - 40
No. 200	0 - 10

1.3 EXECUTION

A. Soundness: Materials furnished under this item shall be substantially free of shale, organic or other soft, poor durability particles. A visual inspection of particle composition by the Owner will generally be the basis for acceptance. Where the Owner elects to test for this requirement, a Magnesium Sulfate Soundness Loss exceeding 35 percent will be cause for rejection.

B. Contamination: Contamination of the Select Gravel with any deleterious material, such as silt, clay, mud, ice, snow or organic material, through any cause whatsoever, shall be corrected by the Contractor by excavation and replacement of the material in the affected area.

C. Sampling: Samples and certified gradations shall be furnished by the Contractor to the Owner and approval of these samples must be received prior to delivery or placement of the material.

D. Compaction:
1. All material shall be placed in uniform horizontal layers not exceeding 6-inches thickness before compaction. All portions of each layer shall be mechanically compacted to the percentage of the Standard Proctor Maximum Density (AASHTO T-99) as follows, unless noted otherwise. Compaction equipment approval shall be made by the Owner.
2. Density determination.
   a. Structures (entire area within 10 feet outside perimeter) 95%
   b. Building Slabs and Steps: 95%
   c. Lawn or Unpaved Areas: 90%
   d. Pavements and Walkways: 95%
   e. Pipes and Tunnels: 95%
   f. Pipe Bedding: 100%

END OF SECTION 32 11 16 16b

Task	Specification	Specification Description
32 11 23 16	32 11 16 16	Crushed Stone Paving
32 11 23 16	32 11 16 16a	Crushed Stone
32 11 23 16	32 11 16 16b	Select Gravel

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SECTION 32 12 13 13 - BITUMINOUS PAVING-REPAIR AND RESURFACING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials repair and resurfacing of bituminous pavements. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Reports: Copies of test results, within 24 hours after completion of tests.
2. Waybills and Delivery Tickets: Copies of waybills or delivery tickets, during the progress of the work.

1.2 PRODUCTS:

A. Asphaltic Concrete:
1. Hot-Mixed, Hot-Mixed Asphaltic Concrete and Emulsified asphalt shall comply with requirements of ASTM D 3515.
2. Plant-Mixed, Stockpiled Asphalt Cold Mixes shall comply with the requirements of Asphalt Institute Specification PM-2.

B. Bituminous Prime: Bituminous primer shall comply with ASTM D 2027.

C. Base Course: Base course material shall comply with State highway department specification for dense-graded, high-quality material.

D. Bituminous Tack Coat: Bituminous tack coat shall comply with ASTM D 2027.

1.3 EXECUTION:

A. Preparation of Areas for Patching:
1. Pot Holes: Trim the perimeter of each hole to a vertical face with a carborundum blade in a square or rectangular pattern at least 18 inches from ragged edge. Remove material to a depth that provides a uniform well-compacted bottom surface. Remove all loose material resulting from trimming or otherwise existing in the hole. If subbase is disturbed, reestablish in a like manner to adjacent substrate. Areas to be repaired shall be dry before repair is started.
2. Alligator-Cracked and Rutted Areas: The pavement shall be sawed or cut with pavement breakers to a smooth vertical face 18 inches outside of the alligator-cracked area. Unsatisfactory material shall be removed in a manner not to disturb the sides of the excavated area.
3. Slippage Areas: Saw a rectangular area around the slippage area that overlaps into the well-bonded material by at least 18 inches. The depth of the saw cut shall be equal to the thickness of the layer of material that is slipping. The surface where slipping is occurring shall be broomed clean and all loose material removed.

B. Installation:
1. Application Temperatures: Application temperatures for all asphalt material shall comply with provisions of the Asphalt Institute Publications and the applicable ASTM Standards.

2. Base Course: Place base course material in layers not exceeding a compacted thickness of 6 inches. After placing, compact each layer by mechanical compactors to a density of not less than the density of the corresponding layer of the adjacent pavement structure.
3. Prime Coat: Prime base course with MC-70 liquid asphalt at a rate of 0.20 to 0.30 gallon per sq. yd. Bolt excess prime with sand before the surfacing material is applied.
4. Tack Coat: Give the edges of existing asphaltic concrete or surfaces of Portland cement concrete and asphaltic concrete a tack coat of MC-70 liquid asphalt at a rate of 0.05 to 0.15 gallon per sq. yd. Allow the material to cure before placing the surfacing material.
5. Hot-Mixed Asphaltic Concrete: Place the material in layers not exceeding 2-1/2 inches in thickness and compact to a density equal to the density of the adjacent asphaltic concrete.
6. Stockpiled Cold Mixes: The compacted thickness of each layer of material shall not exceed 2 inches. Before compaction, the material shall be allowed to aerate, if necessary, until the proper amount of cohesion has developed to obtain adequate compaction. When more than one layer is used, each layer shall be thoroughly cured before the succeeding layer is placed.

END OF SECTION 32 12 13 13

SECTION 32 12 13 13a - ASPHALTIC CONCRETE OVERLAYS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of asphaltic concrete overlays. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Asphalt Cement: The asphalt cement shall comply with ASTM D 946 penetration grade 85-100 requirements and shall show a negative spot test when tested in compliance with AASHTO T 102.

B. Mineral Aggregates: Shall comply with ASTM D 3515 for 3/4-inch maximum aggregate mix.

C. Test Properties: The bituminous mixture shall meet the following requirements when tested in compliance with MIL-STD 620.

Stability minimum, lb	500
Flow maximum, 1/100-in. units	20
Voids total mix, %	3-5
Voids filled with bitumen, %	75-85

1.3 EXECUTION

A. Preparation of Existing Surface: The Contractor shall raise and reset all structures such as manhole frames, valve boxes, drainage structures, etc., to meet the required grade. An asphalt tack coat shall be applied to all contact surfaces in advance of the asphalt concrete overlay placement. The asphalt tack shall be placed at an asphalt residue coverage rate of 0.05 gal/sq yd.

B. Installation:
1. Joints: Longitudinal joints of the overlay shall be offset at least 1 foot from existing joints. Transverse joints shall be offset at least 2 feet from existing transverse joints.
2. All Asphalt Concrete Mixture and Pavement that are contaminated, damaged, or defective shall be removed and replaced by the Contractor. Skin patching of rolled pavement will not be permitted.
3. Compaction of Mixture: The asphalt concrete mixture shall be rolled until a density of not less than 95 percent and not more than 100 percent of laboratory compacted specimen is obtained.
4. Surface Smoothness: After final rolling, the pavement surface shall not vary in excess of 1/8 inch from a 10-foot straightedge laid on the surface.

END OF SECTION 32 12 13 13a

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Task	Specification	Specification Description
32 12 13 13	32 01 13 61	Asphalt Paving
32 12 13 19	32 01 13 61	Asphalt Paving
32 12 13 19	32 12 13 13	Bituminous Paving-Repair And Resurfacing
32 12 13 19	32 12 13 13a	Asphaltic Concrete Overlays
32 12 16 13	32 01 13 61	Asphalt Paving
32 12 16 13	32 12 13 13	Bituminous Paving-Repair And Resurfacing
32 12 16 13	32 12 13 13a	Asphaltic Concrete Overlays
32 12 16 19	32 12 13 13	Bituminous Paving-Repair And Resurfacing
32 12 16 19	32 12 13 13a	Asphaltic Concrete Overlays
32 12 16 39	31 32 13 16	Soil Stabilization-Lime
32 12 16 39	31 25 14 13	Geosynthetic Fabric
32 12 16 43	32 01 13 61	Asphalt Paving
32 12 16 43	32 01 13 61a	Crack Sealing Of Bituminous Pavements
32 12 16 43	32 01 13 61b	Spray Applications, Seal Coats, And Surface Treatments
32 12 33 00	32 01 13 61	Asphalt Paving
32 12 33 00	32 12 13 13	Bituminous Paving-Repair And Resurfacing
32 12 33 00	32 12 13 13a	Asphaltic Concrete Overlays
32 12 36 13	32 01 13 61	Asphalt Paving
32 12 36 13	32 01 13 61a	Crack Sealing Of Bituminous Pavements
32 12 36 16	32 01 13 61	Asphalt Paving
32 12 36 16	32 01 13 61a	Crack Sealing Of Bituminous Pavements
32 12 36 16	32 01 13 61b	Spray Applications, Seal Coats, And Surface Treatments
32 12 36 23	32 01 13 61	Asphalt Paving
32 12 36 23	32 01 13 61a	Crack Sealing Of Bituminous Pavements
32 12 36 23	32 01 13 61b	Spray Applications, Seal Coats, And Surface Treatments

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SECTION 32 13 13 33 - DECORATIVE CEMENT CONCRETE PAVEMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for decorative cement concrete pavement. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes colored, stamped, stenciled, and stained concrete paving.

C. Definitions
1. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

D. Submittals
1. Product Data: For each type of product indicated.
2. LEED Submittals:
   a. Product Data for Credit MR 4.1 and Credit MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating costs for each product having recycled content.
   b. Design Mixtures for Credit ID 1.1: For each concrete mixture containing fly ash as a replacement for portland cement or other portland cement replacements. For each design mixture submitted, include an equivalent concrete mixture that does not contain portland cement replacements, to determine amount of portland cement replaced.
3. Samples: For each type of exposed color, pattern, or texture indicated.
4. Other Action Submittals:
   a. Design Mixtures: For each decorative concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
5. Qualification Data: For qualified Installer, ready-mix concrete manufacturer, and testing agency.
6. Material Certificates: For the following, from manufacturer:
   a. Cementitious materials.
   b. Steel reinforcement and reinforcement accessories.
   c. Fiber reinforcement.
   d. Admixtures.
   e. Curing compounds.
   f. Applied finish materials.
   g. Bonding agent or epoxy adhesive.
   h. Joint fillers.
7. Material Test Reports: For each of the following:
   a. Aggregates. Include service-record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.
8. Field quality-control reports.

E. Quality Assurance
1. Installer Qualifications: An employer of workers trained and approved by manufacturer of decorative concrete paving systems.
2. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

a. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual - Section 3, "Plant Certification Checklist").

3. Testing Agency Qualifications: Qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
   a. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.
4. Source Limitations: Obtain decorative concrete paving products and each type or class of cementitious material of the same brand from same manufacturer's plant, and obtain each aggregate from single source.
5. Concrete Testing Service: Engage a qualified testing agency to perform material evaluation tests and to design concrete mixtures.
6. ACI Publications: Comply with ACI 301 (ACI 301M) unless otherwise indicated.
7. Preinstallation Conference: Conduct conference at Project site.

F. Project Conditions
1. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

1.2 PRODUCTS

A. Forms
1. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.
   a. Use flexible or uniformly curved forms for curves of a radius of 100 feet (30.5 m) or less. Do not use notched and bent forms.
2. Forms for Textured Finish Concrete: Units of face design, size, arrangement, and configuration indicated. Provide solid backing and form supports to ensure stability of textured form liners.
3. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

B. Steel Reinforcement
1. Recycled Content: Provide steel reinforcement with an average recycled content of steel so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
2. Plain-Steel Welded Wire Reinforcement: ASTM A 1064/A 1064M, fabricated from as-drawn steel wire into flat sheets.
3. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420); deformed.
4. Steel Bar Mats: ASTM A 184/A 184M; with ASTM A 615/A 615M, Grade 60 (Grade 420), deformed bars; assembled with clips.
5. Plain-Steel Wire: ASTM A 82/A 82M, as drawn.
6. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 (Grade 420) plain-steel bars. Cut bars true to length with ends square and free of burrs.
7. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:
   a. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.

C. Concrete Materials
1. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source, throughout Project:

a. Portland Cement: ASTM C 150, gray **OR** white, **as directed**, portland cement Type I **OR** Type II **OR** Type I/II **OR** Type III **OR** Type V, **as directed**. Supplement with the following, **as directed**:
   1) Fly Ash: ASTM C 618, Class C or F.
   2) Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
b. Blended Hydraulic Cement: ASTM C 595, Type IS, portland blast-furnace slag **OR** Type IP, portland-pozzolan, **as directed**, cement.

2. Normal-Weight Aggregates: ASTM C 33, Class 4S **OR** Class 4M **OR** Class 1N, **as directed**, uniformly graded. Provide aggregates from a single source with documented service-record data of at least 10 years' satisfactory service in similar paving applications and service conditions using similar aggregates and cementitious materials, **as directed**.
   a. Maximum Aggregate Size: 1-1/2 inches (38 mm) **OR** 1 inch (25 mm) **OR** 3/4 inch (19 mm), **as directed**, nominal.
   b. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
3. Water: Potable and complying with ASTM C 94/C 94M.
4. Air-Entraining Admixture: ASTM C 260.
5. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.
   a. Water-Reducing Admixture: ASTM C 494/C 494M, Type A, colored, **as directed**.
   b. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D, colored, **as directed**.
   c. Water-Reducing and Accelerating Admixture: ASTM C 494/C 494M, Type E.
6. Color Pigment: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, free of carbon black, **as directed**, nonfading, and resistant to lime and other alkalis.

D. Fiber Reinforcement
1. Synthetic Fiber: Monofilament or fibrillated polypropylene fibers engineered and designed for use in decorative concrete paving, complying with ASTM C 1116/C 1116M, Type III, 1/2 to 1-1/2 inches (13 to 38 mm) long.

E. Surface Coloring Materials
1. Pigmented Mineral Dry-Shake Hardener: Factory-packaged, dry combination of portland cement, graded quartz aggregate, color pigments, and plasticizing admixture. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.
2. Pigmented Powder Release Agent: Factory-packaged, dry combination of surface-conditioning and dispersing agents interground with color pigments that facilitates release of stamp mats. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.
3. Liquid Release Agent: Manufacturer's standard, clear, evaporating formulation that facilitates release of stamp mats and texture rollers.

F. Stamping Devices
1. Stamp Mats: Semirigid polyurethane mats with projecting textured and ridged underside capable of imprinting texture and joint patterns on plastic concrete.
2. Stamp Tools: Open-grid, aluminum or rigid-plastic stamp tool capable of imprinting joint patterns on plastic concrete.
3. Rollers: Manually controlled, water-filled aluminum rollers with projecting ridges on drum capable of imprinting texture and joint patterns on plastic concrete.
4. Texture Rollers: Manually controlled, abrasion-resistant polyurethane rollers capable of imprinting texture on plastic concrete.

G. Stencil Materials
1. Stencils: Manufacturer's standard, moisture-resistant paper or reusable plastic stencils, designed for use on plastic concrete.

H. Stain Materials
1. Reactive Stain: Acidic-based stain with wetting agents and high-grade, UV-stable metallic salts that react with calcium hydroxide in cured concrete to produce permanent, variegated, or translucent color effects.
2. Penetrating Stain: Water-based, acrylic latex, penetrating stain with colorfast pigments.

I. Curing And Sealing Materials
1. Curing Paper: Nonstaining, waterproof paper, consisting of two layers of kraft paper cemented together and reinforced with fiber, and complying with ASTM C 171.
2. Evaporation Retarder: Waterborne, monomolecular, film forming, manufactured for application to fresh concrete.
3. Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type I, Class B, manufactured for colored concrete.
   a. For integrally colored concrete, curing compound shall be pigmented type approved by coloring admixture manufacturer.
   b. For concrete indicated to be sealed, curing compound shall be compatible with sealer.
4. Clear, Solvent-Borne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type I, Class A, manufactured for use with colored concrete.
5. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type I, Class A, manufactured for use with colored concrete.
6. Clear Acrylic Sealer: Manufacturer's standard, waterborne, nonyellowing and UV-resistant, membrane-forming, medium-gloss, acrylic copolymer emulsion solution, manufactured for colored concrete, containing not less than 15 percent solids by volume.
7. Slip-Resistance-Enhancing Additive: Manufacturer's standard finely graded aggregate or polymer additive, designed to be added to clear acrylic sealer to enhance slip resistance of sealed paving surface.

J. Related Materials
1. Joint Fillers: ASTM D 1751, asphalt-saturated cellulosic fiber or ASTM D 1752, cork or self-expanding cork in preformed strips.
2. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
3. Epoxy Bonding Adhesive: ASTM C 881/C 881M, two-component epoxy resin capable of humid curing and bonding to damp surfaces; of class suitable for application temperature, of grade complying with requirements, and of the following types:
   a. Types I and II, non-load bearing **OR** Types IV and V, load bearing, **as directed**, for bonding hardened or freshly mixed concrete to hardened concrete.
4. Polyethylene Film: ASTM D 4397, 1 mil (0.025 mm) thick, clear.

K. Concrete Mixtures
1. Prepare design mixtures, proportioned according to ACI 301 (ACI 301M), for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.
   a. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.
2. Proportion mixtures to provide normal-weight concrete with the following properties:
   a. Compressive Strength (28 Days): 4500 psi (31 MPa) **OR** 4000 psi (27.6 MPa) **OR** 3500 psi (24.1 MPa) **OR** 3000 psi (20.7 MPa), **as directed**.
   b. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.45 **OR** 0.50, **as directed**.
   c. Slump Limit: 4 inches (100 mm) **OR** 5 inches (125 mm), **as directed**, plus or minus 1 inch (25 mm).
3. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:
   a. Air Content: 5-1/2 **OR** 4-1/2 **OR** 2-1/2, **as directed**, percent plus or minus 1.5 percent for 1-1/2-inch (38-mm) nominal maximum aggregate size.

b. Air Content: 6 **OR** 4-1/2 **OR** 3, **as directed**, percent plus or minus 1.5 percent for 1-inch (25-mm) nominal maximum aggregate size.
c. Air Content: 6 **OR** 5 **OR** 3-1/2, **as directed**, percent plus or minus 1.5 percent for 3/4-inch (19-mm) nominal maximum aggregate size.

4. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 **OR** 0.30, **as directed**, percent by weight of cement.
5. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
   a. Use water-reducing admixture **OR** water-reducing and retarding admixture **OR** water-reducing and accelerating admixture, **as directed**, in concrete as required for placement and workability.
   b. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
6. Cementitious Materials: Limit percentage by weight of cementitious materials other than portland cement according to ACI 301 (ACI 301M) requirements for concrete exposed to deicing chemicals **OR** as follows, **as directed**:
   a. Fly Ash or Pozzolan: 25 percent.
   b. Ground Granulated Blast-Furnace Slag: 50 percent.
   c. Combined Fly Ash or Pozzolan, and Ground Granulated Blast-Furnace Slag: 50 percent, with fly ash or pozzolan not exceeding 25 percent.
7. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than 1.0 lb/cu. yd. (0.60 kg/cu. m).
8. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

L. Concrete Mixing
1. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M and ASTM C 1116/C 1116M, **as directed**. Furnish batch certificates for each batch discharged and used in the Work.
   a. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.
2. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.
   a. For concrete batches of 1 cu. yd. (0.76 cu. m) or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
   b. For concrete batches larger than 1 cu. yd. (0.76 cu. m), increase mixing time by 15 seconds for each additional 1 cu. yd. (0.76 cu. m).
   c. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

1.3 EXECUTION

A. Examination
1. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.
2. Proof-roll prepared subbase surface below decorative concrete paving to identify soft pockets and areas of excess yielding.
   a. Completely proof-roll subbase in one direction and repeat in perpendicular direction. Limit vehicle speed to 3 mph (5 km/h).
   b. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons (13.6 tonnes).
   c. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch (13 mm) according to requirements in Division 31 Section "Earth Moving".

3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation
1. Remove loose material from compacted subbase surface immediately before placing concrete.
2. Protect adjacent construction from discoloration and spillage during application of color hardeners, release agents, stains, curing compounds, and sealers.

C. Edge Forms And Screed Construction
1. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
2. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

D. Steel Reinforcement
1. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
2. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
3. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.
4. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.
5. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch (50-mm) overlap to adjacent mats.

E. Joints
1. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
   a. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.
2. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
   a. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
   b. Butt Joints: Use bonding agent **OR** epoxy bonding adhesive, **as directed**, at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
   c. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least 1-1/2 inches (38 mm) into concrete.
   d. Dowelled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
3. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.
   a. Locate expansion joints at intervals of 50 feet (15.25 m) unless otherwise indicated.
   b. Extend joint fillers full width and depth of joint.
   c. Terminate joint filler not less than 1/2 inch (13 mm) or more than 1 inch (25 mm) below finished surface if joint sealant is indicated.
   d. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
   e. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.

f. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

4. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows, to match jointing of existing adjacent decorative concrete paving, **as directed**:
   a. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 1/4-inch (6-mm) **OR** 3/8-inch (10-mm), **as directed**, radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate grooving-tool marks on concrete surfaces.
      1) Tolerance: Ensure that grooved joints are within 3 inches (75 mm) either way from centers of dowels.
   b. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- (3-mm-) wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
      1) Tolerance: Ensure that sawed joints are within 3 inches (75 mm) in both directions from center of dowels.
   c. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
5. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch (6-mm) **OR** 3/8-inch (10-mm), **as directed**, radius. Repeat tooling of edges after applying surface finishes. Eliminate edging tool marks on concrete surfaces.

F. Concrete Placement
1. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.
2. Remove snow, ice, or frost from subbase surface and steel reinforcement before placing concrete. Do not place concrete on frozen surfaces.
3. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.
4. Comply with ACI 301 (ACI 301M) requirements for measuring, mixing, transporting, and placing concrete.
5. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.
6. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
7. Consolidate concrete according to ACI 301 (ACI 301M) by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
   a. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement, dowels, and joint devices.
8. Screed paving surface with a straightedge and strike off.
9. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.
10. Cold-Weather Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:
    a. When air temperature has fallen to or is expected to fall below 40 deg F (4.4 deg C), uniformly heat water and aggregates before mixing to obtain a concrete mixture

temperature of not less than 50 deg F (10 deg C) and not more than 80 deg F (27 deg C) at point of placement.

b. Do not use frozen materials or materials containing ice or snow.

c. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.

11. Hot-Weather Placement: Comply with ACI 301 (ACI 301M) and as follows when hot-weather conditions exist:

a. Cool ingredients before mixing to maintain concrete temperature below 90 deg F (32 deg C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.

b. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.

c. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

G. Float Finishing

1. General: Do not add water to concrete surfaces during finishing operations.
2. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

H. Integrally Colored Concrete Finish

1. Integrally Colored Concrete Finish: After final floating, apply the following finish:
   a. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
   b. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.
   c. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch (1.6 to 3 mm) deep with a stiff-bristled broom, perpendicular to line of traffic.

I. Stenciling

1. Cut stencils to slab width and lay on wet concrete. Overlap "mortar joint" on trailing edge of each section of stencil onto leading "mortar joint" of previous section.
2. Trim stencils to fit slab and adjacent patterns.
3. Slightly embed stencil into concrete by rolling with stencil roller.
4. Apply pigmented mineral dry-shake hardener materials to concrete surfaces according to manufacturer's written instructions.
5. Stencil Rolling:
   a. Apply pigmented powder release agent **OR** liquid release agent, **as directed**, according to manufacturer's written instructions prior to applying texture roller to surface of concrete.
   b. Perform rolling operation to produce required texture on concrete surface.
6. Remove stencils when concrete has sufficiently cured to bear weight. Do not leave stencils in concrete overnight.
7. Remove debris with mechanical blower prior to application of curing compound. If release agent is applied, delay removal of debris for 24 hours, then flood area with low-pressure water hose, wetting release agent, and follow by cleaning surface with pressure washer.

J. Pigmented Mineral Dry-Shake Hardener

1. Pigmented Mineral Dry-Shake Hardener Finish: After initial floating, apply dry-shake materials to paving surfaces according to manufacturer's written instructions and as follows:

a. Uniformly apply dry-shake hardener at a rate of 100 lb/100 sq. ft. (49 kg/10 sq. m) unless greater amount is recommended by manufacturer to match paving color required.
b. Uniformly distribute approximately two-thirds of dry-shake hardener over the concrete surface with mechanical spreader; allow hardener to absorb moisture and embed it by power floating. Follow power floating with a second application of pigmented mineral dry-shake hardener, uniformly distributing remainder of material at right angles to first application to ensure uniform color, and embed hardener by final power floating.
c. After final power floating, apply the following finish:
1) Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
2) Medium-to-Fine-Textured Broom Finish: Draw a soft bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.
3) Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch (1.6 to 3 mm) deep with a stiff-bristled broom, perpendicular to line of traffic.

2. Pigmented Powder Release Agent: Uniformly distribute onto dry-shake-hardened and still-plastic concrete at a rate of 3 to 4 lb/100 sq. ft. (1.5 to 2 kg/10 sq. m).
3. Liquid Release Agent: Uniformly mist surface of dry-shake-hardened and still-plastic concrete at a rate of 5 gal/1000 sq. ft. (0.2 L/sq. m).

K. Stamping
1. Mat Stamping: After floating and while concrete is plastic, apply mat-stamped finish.
a. Pigmented Powder Release Agent: Uniformly distribute onto concrete at a rate of 3 to 4 lb/100 sq. ft. (1.5 to 2 kg/10 sq. m).
b. Liquid Release Agent: Apply liquid release agent to the concrete surface and the stamp mat. Uniformly mist surface of concrete at a rate of 5 gal/1000 sq. ft. (0.2 L/sq. m).
c. After application of release agent, accurately align and place stamp mats in sequence.
d. Uniformly load mats and press into concrete to produce required imprint pattern and depth of imprint on concrete surface. Gently remove stamp mats. Hand stamp edges and surfaces unable to be imprinted by stamp mats.
e. Remove residual release agent according to manufacturer's written instructions, but no fewer than three days after stamping concrete. High-pressure-wash surface and joint patterns, taking care not to damage stamped concrete. Control, collect, and legally dispose of runoff.
2. Tool Stamping: After floating and while concrete is plastic, apply tool-stamped finish.
a. Cover surface with polyethylene film, stretch taut to remove wrinkles, lap sides and ends 3 inches (75 mm), and secure to edge forms. Lightly broom surface to remove air bubbles.
b. Accurately align and place stamp tools in sequence and tamp into concrete to produce required imprint pattern and depth of imprint on concrete surface. Gently remove stamp tools. Hand stamp edges and surfaces unable to be imprinted by stamp tools.
c. Carefully remove polyethylene film immediately after tool stamping.
3. Roller Stamping: After floating and while concrete is plastic, apply roller-stamped finish.
a. Cover surface with polyethylene film, stretch taut to remove wrinkles, lap sides and ends 3 inches (75 mm), and secure to edge forms. Lightly broom surface to remove air bubbles.
b. Accurately align roller and perform rolling operation to produce required imprint pattern and depth of imprint on concrete surface. Hand stamp surfaces inaccessible to roller.
c. Carefully remove polyethylene film immediately after roller stamping.

L. Concrete Protection And Curing
1. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
2. Comply with ACI 306.1 for cold-weather protection.
3. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during

finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

4. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.
5. Curing Compound: Apply curing compound immediately after final finishing. Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas that have been subjected to heavy rainfall within three hours after application. Maintain continuity of coating, and repair damage during curing period.
   a. Cure integrally colored concrete with a pigmented, **as directed**, curing compound.
   b. Cure concrete finished with pigmented mineral dry-shake hardener with a pigmented, **as directed**, curing compound.
6. Curing and Sealing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.
7. Curing Paper: Cure with unwrinkled curing paper in pieces large enough to cover the entire width and edges of slab. Do not lap sheets. Fold curing paper down over paving edges and secure with continuous banks of earth to prevent displacement or billowing due to wind. Immediately repair holes or tears in paper.

M. Staining
1. Newly placed concrete paving shall be at least 14 **OR** 30, **as directed**, days old before staining.
2. Prepare surfaces according to manufacturer's written instructions and as follows:
   a. Clean concrete thoroughly by scraping, applying solvents or stripping agents, sweeping and pressure washing, or scrubbing with a rotary floor machine and detergents recommended by stain manufacturer. Rinse until water is clear and allow surface to dry.
      1) Do not use acidic solutions to clean surfaces.
   b. Test surfaces with droplets of water. If water beads and does not penetrate surface, or penetrates only in some areas, profile surfaces by acid etching, grinding, sanding, or abrasive blasting. Retest and continue profiling surface until water droplets immediately darken and uniformly penetrate concrete surfaces.
   c. Apply acidic solution to dampened concrete surfaces, scrubbing with uncolored, acid-resistant nylon-bristle brushes until bubbling stops and concrete surface has texture of 120-grit sandpaper. Do not allow solution to dry on concrete surfaces. Rinse until water is clear. Control, collect, and legally dispose of runoff.
   d. Neutralize concrete surfaces and rinse until water is clear. Test surface for residue with clean white cloth. Test surface according to ASTM F 710 to ensure pH is between 7 and 8.
3. Scoring: Score decorative jointing in paving surfaces 1/16 inch (1.6 mm) deep with diamond blades to match pattern indicated. Rinse until water is clear. Score after **OR** before, **as directed**, staining.
   a. Joint Width: 3/8 inch (10 mm).
4. Allow paving surface to dry before applying stain. Verify readiness of paving to receive stain according to ASTM D 4263 by tightly taping 18-by-18-inch (450-by-450-mm), 4-mil- (0.1-mm-) thick polyethylene sheet to a representative area of paving surface. Apply stain only if no evidence of moisture has accumulated under sheet after 16 hours.
5. Reactive Stain: Apply reactive stain to paving surfaces according to manufacturer's written instructions and as follows:
   a. Apply stain by uncolored bristle brush, roller, or high-volume, low-pressure sprayer and immediately scrub into concrete surface with uncolored, acid-resistant nylon-bristle brushes in continuous, circular motion. Do not spread stain after fizzing stops. Allow to dry four hours and repeat application of stain in sufficient quantity to obtain color consistent with approved mockup.
   b. Remove stain residue after four hours by wet scrubbing with commercial-grade detergent recommended by stain manufacturer. Rinse until water is clear. Control, collect, and legally dispose of runoff.

6. Penetrating Stain: Apply penetrating stain to paving surfaces according to manufacturer's written instructions and as follows:
   a. Apply first coat of stain to dry, clean surfaces by airless sprayer or by high-volume, low-pressure sprayer.
   b. Allow to dry four hours and repeat application of stain in sufficient quantity to obtain color consistent with approved mockup.
   c. Rinse until water is clear. Control, collect, and legally dispose of runoff.

N. Sealer
1. Clear Acrylic Sealer: Apply uniformly in two coats in continuous operations according to manufacturer's written instructions. Allow first coat to dry before applying second coat, at 90 degrees to the direction of the first coat using same application methods and rates.
   a. Begin sealing dry surface no sooner than 14 days after concrete placement.
   b. Allow stained concrete surfaces to dry before applying sealer.
   c. Thoroughly mix slip-resistance-enhancing additive into sealer before applying sealer according to manufacturer's written instructions. Stir sealer occasionally during application to maintain even distribution of additive.

O. Paving Tolerances
1. Comply with tolerances in ACI 117 and as follows:
   a. Elevation: 3/4 inch (19 mm).
   b. Thickness: Plus 3/8 inch (10 mm), minus 1/4 inch (6 mm).
   c. Surface: Gap below 10-foot- (3-m-) long, unleveled straightedge not to exceed 1/2 inch (13 mm).
   d. Lateral Alignment and Spacing of Dowels: 1 inch (25 mm).
   e. Vertical Alignment of Dowels: 1/4 inch (6 mm).
   f. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 inch per 12 inches (6 mm per 300 mm) of dowel.
   g. Joint Spacing: 3 inches (75 mm).
   h. Contraction Joint Depth: Plus 1/4 inch (6 mm), no minus.
   i. Joint Width: Plus 1/8 inch (3 mm), no minus.

P. Field Quality Control
1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
2. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:
   a. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. (76 cu. m) **OR** 5000 sq. ft. (465 sq. m), **as directed**, or fraction thereof of each concrete mixture placed each day.
      1) When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
   b. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
   c. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
   d. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and when it is 80 deg F (27 deg C) and above, and one test for each composite sample.
   e. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
   f. Compressive-Strength Tests: ASTM C 39/C 39M; test one specimen at seven days and two specimens at 28 days.
      1) A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.

3. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa).
4. Test results shall be reported in writing to the Owner, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
5. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by the Owner but will not be used as sole basis for approval or rejection of concrete.
6. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by the Owner.
7. Decorative concrete paving will be considered defective if it does not pass tests and inspections.
8. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
9. Prepare test and inspection reports.

Q. Repairs And Protection
1. Remove and replace decorative concrete paving that is broken or damaged or does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by the Owner.
2. Detailing: Grind concrete "squeeze" left from tool placement. Color ground areas with slurry of color hardener mixed with water and bonding agent. Remove excess release agent with high-velocity blower.
3. Protect decorative concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.
4. Maintain decorative concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Final Completion inspections.

END OF SECTION 32 13 13 33

Task	Specification	Specification Description
32 13 13 33	03 31 13 00	Cement Concrete Pavement
32 13 13 33	03 31 13 00a	Roller Compacted Concrete Pavement
32 13 13 33	03 31 13 00c	Steel Reinforced Portland Cement Concrete Overlays
32 13 13 33	03 31 13 00d	Fiber Reinforced Portland Cement Concrete Overlays
32 13 73 13	32 01 13 61	Asphalt Paving
32 13 73 13	32 01 13 61a	Crack Sealing Of Bituminous Pavements
32 13 73 13	32 01 13 61b	Spray Applications, Seal Coats, And Surface Treatments
32 13 73 16	32 01 13 61	Asphalt Paving
32 13 73 16	32 01 13 61a	Crack Sealing Of Bituminous Pavements
32 13 73 16	32 01 13 61b	Spray Applications, Seal Coats, And Surface Treatments
32 13 73 19	32 01 13 61	Asphalt Paving
32 13 73 19	32 01 13 61b	Spray Applications, Seal Coats, And Surface Treatments

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SECTION 32 14 09 00 - EXTERIOR PLANTS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for exterior plants. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Plants.
b. Planting soils.
c. Tree stabilization.
d. Landscape edgings.
e. Tree grates.

C. Definitions
1. Backfill: The earth used to replace or the act of replacing earth in an excavation.
2. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with ball size not less than sizes indicated **OR** diameter and depth recommended by ANSI Z60.1 for type and size of plant required, **as directed**; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.
3. Balled and Potted Stock: Plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is not less than sizes indicated **OR** diameter and depth recommended by ANSI Z60.1 for type and size of plant required, **as directed**.
4. Bare-Root Stock: Plants with a well-branched, fibrous-root system developed by transplanting or root pruning, with soil or growing medium removed, and with not less than minimum root spread according to ANSI Z60.1 for type and size of plant required.
5. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.
6. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.
7. Fabric Bag-Grown Stock: Healthy, vigorous, well-rooted plants established and grown in-ground in a porous fabric bag with well-established root system reaching sides of fabric bag. Fabric bag size is not less than diameter, depth, and volume required by ANSI Z60.1 for type and size of plant.
8. Finish Grade: Elevation of finished surface of planting soil.
9. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
10. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
11. Pests: Living organisms that occur where they are not desired, or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
12. Planting Area: Areas to be planted.

13. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
14. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.
15. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.
16. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.
17. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.
18. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
19. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.

D. Submittals
1. Product Data: For each type of product indicated, including soils.
2. Samples of mineral mulch.
3. Product certificates.
4. Maintenance Instructions: Recommended procedures to be established by the Owner for maintenance of plants during a calendar year.

E. Quality Assurance
1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
   a. Pesticide Applicator: State licensed, commercial.
2. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory.
   a. The soil-testing laboratory shall oversee soil sampling.
   b. Report suitability of tested soil for plant growth.
      1) State recommendations for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
      2) Report presence of problem salts, minerals, or heavy metals; if present, provide additional recommendations for corrective action.
3. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.
4. Preinstallation Conference: Conduct conference at Project site.

F. Delivery, Storage, And Handling
1. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.
2. Bulk Materials:
   a. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
   b. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   c. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.
3. Deliver bare-root stock plants freshly dug. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting.

4. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.
5. Handle planting stock by root ball.
6. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F (16 to 18 deg C) until planting.
7. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.
   a. Heel-in bare-root stock. Soak roots that are in dry condition in water for two hours. Reject dried-out plants.
   b. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
   c. Do not remove container-grown stock from containers before time of planting.
   d. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly-wet condition.

G. Warranty
1. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.
   a. Failures include, but are not limited to, the following:
      1) Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by the Owner, or incidents that are beyond Contractor's control.
      2) Structural failures including plantings falling or blowing over.
      3) Faulty performance of tree stabilization, edgings, or tree grates.
      4) Deterioration of metals, metal finishes, and other materials beyond normal weathering.
   b. Warranty Periods from Date of Planting Completion **OR** Final Completion, **as directed**:
      1) Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
      2) Ground Covers, Biennials, Perennials, and Other Plants: 12 **OR** Nine **OR** Six **OR** Three, **as directed**, months.
      3) Annuals: Three **OR** Two, **as directed**, months.

H. Maintenance Service
1. Initial Maintenance Service: Provide maintenance by skilled employees of landscape Installer. Maintain as required in Part 1.3. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established but for not less than maintenance period below.
   a. Maintenance Period for Trees and Shrubs: 12 **OR** Six **OR** Three, **as directed**, months from date of planting completion **OR** Final Completion, **as directed**.
   b. Maintenance Period for Ground Cover and Other Plants: Six **OR** Three, **as directed**, months from date of planting completion **OR** Final Completion, **as directed**.
2. Continuing Maintenance Proposal: From Installer to the Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

1.2 PRODUCTS

A. Plant Material

1. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant Schedule or Plant Legend shown on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
   a. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch (19 mm) in diameter; or with stem girdling roots will be rejected.
   b. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
2. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which shall begin at root flare according to ANSI Z60.1. Root flare shall be visible before planting.
3. Annuals and Biennials: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery and that are in bud but not yet in bloom.

B. Inorganic Soil Amendments
1. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
   a. Class: T, with a minimum of 99 percent passing through No. 8 (2.36-mm) sieve and a minimum of 75 percent passing through No. 60 (0.25-mm) sieve.
   OR
   Class: O, with a minimum of 95 percent passing through No. 8 (2.36-mm) sieve and a minimum of 55 percent passing through No. 60 (0.25-mm) sieve.
   b. Provide lime in form of ground dolomitic limestone **OR** calcitic limestone **OR** mollusk shells, **as directed**.
2. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent sulfur, with a minimum of 99 percent passing through No. 6 (3.35-mm) sieve and a maximum of 10 percent passing through No. 40 (0.425-mm) sieve.
3. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.
4. Aluminum Sulfate: Commercial grade, unadulterated.
5. Perlite: Horticultural perlite, soil amendment grade.
6. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through No. 50 (0.30-mm) sieve.
7. Sand: Clean, washed, natural or manufactured, and free of toxic materials.
8. Diatomaceous Earth: Calcined, 90 percent silica, with approximately 140 percent water absorption capacity by weight.
   OR
   Zeolites: Mineral clinoptilolite with at least 60 percent water absorption by weight.

C. Organic Soil Amendments
1. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch (25-mm) **OR** 3/4-inch (19-mm) **OR** 1/2-inch (13-mm), **as directed**, sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
   a. Organic Matter Content: 50 to 60 percent of dry weight.
   b. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
2. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or granular texture, with a pH range of 3.4 to 4.8.

3. Muck Peat: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1100 to 2000 percent.
4. Wood Derivatives: Decomposed, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.
   a. In lieu of decomposed wood derivatives, mix partially decomposed wood derivatives with ammonium nitrate at a minimum rate of 0.15 lb/cu. ft. (2.4 kg/cu. m) of loose sawdust or ground bark, or with ammonium sulfate at a minimum rate of 0.25 lb/cu. ft. (4 kg/cu. m) of loose sawdust or ground bark.
5. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, debris, and material harmful to plant growth.

D. Fertilizers
1. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 1 **OR** 4, **as directed**, percent nitrogen and 10 **OR** 20, **as directed**, percent phosphoric acid.
2. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
3. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
   a. Composition: 1 lb/1000 sq. ft. (0.45 kg/92.9 sq. m) of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
   b. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.
4. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
   a. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
   b. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.
5. Planting Tablets: Tightly compressed chip type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.
   a. Size: 5-gram **OR** 10-gram **OR** 21-gram, **as directed**, tablets.
   b. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.
6. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.

E. Planting Soils
1. Planting Soil: ASTM D 5268 topsoil, with pH range of 5.5 to 7, a minimum of 2 percent organic material content **OR** Existing, native surface topsoil formed under natural conditions with the duff layer retained during excavation process **OR** Existing, in-place surface soil **OR** Imported topsoil or manufactured topsoil from off-site sources; do not obtain from agricultural land, bogs or marshes, **as directed**. Verify suitability of soil to produce viable planting soil. Clean soil of roots, plants, sod, stones, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth. Mix soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
   a. Ratio of Loose Compost to Topsoil by Volume: 1:4 **OR** 1:3 **OR** 1:2, **as directed**.
   b. Ratio of Loose Sphagnum **OR** Muck, **as directed**, Peat to Topsoil by Volume: as directed by the Owner.
   c. Ratio of Loose Wood Derivatives to Topsoil by Volume: as directed by the Owner.
   d. Weight of Lime per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.

e. Weight of Sulfur **OR** Iron Sulfate **OR** Aluminum Sulfate, **as directed**, per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.
f. Weight of Agricultural Gypsum per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.
g. Volume of Sand Plus 10 Percent Diatomaceous Earth **OR** Zeolites, **as directed**, per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.
h. Weight of Bonemeal per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.
i. Weight of Superphosphate per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.
j. Weight of Commercial Fertilizer per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.
k. Weight of Slow-Release Fertilizer per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.

F. Mulches
1. Organic Mulch: Shredded hardwood **OR** Ground or shredded bark **OR** Wood and bark chips **OR** Pine straw **OR** Salt hay or threshed straw **OR** Pine needles **OR** Peanut, pecan, and cocoa-bean shells, **as directed**.
2. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch (25-mm) sieve; soluble salt content of 2 to 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings.
3. Mineral Mulch: Rounded riverbed gravel or smooth-faced stone **OR** Crushed stone or gravel **OR** Marble chips **OR** Granite chips, **as directed**.
a. Size Range: 1-1/2 inches (38 mm) maximum, 3/4 inch (19 mm) minimum **OR** 3/4 inch (19 mm) maximum, 1/4 inch (6.4 mm) minimum, **as directed**.
b. Color: Uniform tan-beige color range acceptable to the Owner **OR** Readily available natural gravel color range, **as directed**.

G. Weed-Control Barriers
1. Nonwoven Geotextile Filter Fabric: Polypropylene or polyester fabric, 3 oz./sq. yd. (101g/sq. m) minimum, composed of fibers formed into a stable network so that fibers retain their relative position. Fabric shall be inert to biological degradation and resist naturally-encountered chemicals, alkalis, and acids.
2. Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, 4.8 oz./sq. yd. (162 g/sq. m).

H. Pesticides
1. General: Pesticide registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
2. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
3. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

I. Tree Stabilization Materials
1. Stakes and Guys:
a. Upright and Guy Stakes: Rough-sawn, sound, new hardwood **OR** softwood with specified wood pressure-preservative treatment, **as directed**, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal (38-by-38-mm actual) by length indicated, pointed at one end.
b. Wood Deadmen: Timbers measuring 8 inches (200 mm) in diameter and 48 inches (1200 mm) long, treated with specified wood pressure-preservative treatment.
c. Flexible Ties: Wide rubber or elastic bands or straps of length required to reach stakes or turnbuckles **OR** compression springs, **as directed**.
d. Guys and Tie Wires: ASTM A 641/A 641M, Class 1, galvanized-steel wire, two-strand, twisted, 0.106 inch (2.7 mm) in diameter.

e. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.
f. Guy Cables: Five-strand, 3/16-inch- (4.8-mm-) diameter, galvanized-steel cable, with zinc-coated turnbuckles **OR** compression springs, **as directed**, a minimum of 3 inches (75 mm) long, with two 3/8-inch (10-mm) galvanized eyebolts.
g. Flags: Standard surveyor's plastic flagging tape, white, 6 inches (150 mm) long.
h. Proprietary Staking-and-Guying Devices: Proprietary stake and adjustable tie systems to secure each new planting by plant stem; sized as indicated and per manufacturer's written recommendations.

2. Root-Ball Stabilization Materials:
a. Upright Stakes and Horizontal Hold-Down: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal (38-by-38-mm actual) by length indicated; stakes pointed at one end.
b. Wood Screws: ASME B18.6.1.
c. Proprietary Root-Ball Stabilization Devices: Proprietary at- or below-grade stabilization systems to secure each new planting by root ball; sized per manufacturer's written recommendations unless otherwise indicated.

3. Palm Bracing: Battens or blocks, struts, straps, and protective padding as indicated.
a. Battens or Blocks and Struts: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, 2-by-4-inch nominal (38-by-89-mm actual) by lengths indicated.
b. Straps: Adjustable steel or plastic package banding straps.
c. Padding: Burlap.
d. Proprietary Palm-Bracing Devices: Proprietary systems to secure each new planting by trunk; sized per manufacturer's written recommendations unless otherwise indicated.

J. Landscape Edgings
1. Wood Edging: Of sizes shown on Drawings, and wood stakes as follows:
a. Species: Western red cedar, all heart **OR** Southern pine with specified wood pressure-preservative treatment, **as directed**.
b. Stakes: Same species as edging, 1-by-2-inch nominal (19-by-38-mm actual) by 18 inches (450 mm) long, with galvanized nails for anchoring edging.

2. Steel Edging: Standard commercial-steel edging, rolled edge, fabricated in sections of standard lengths, with loops stamped from or welded to face of sections to receive stakes.
a. Edging Size: 3/16 inch (4.8 mm) wide by 4 inches (100 mm) deep **OR** 1/4 inch (6.4 mm) wide by 5 inches (125 mm) deep **OR** 1/4 inch (6.4 mm) wide by 4 inches (100 mm) deep **OR** 1/8 inch (3.2 mm) wide by 4 inches (100 mm) deep **OR** 1/8 inch (3.2 mm) wide by 6 inches (150 mm) deep **OR** 0.1 inch (2.5 mm) wide by 4 inches (100 mm) deep, **as directed**.
b. Stakes: Tapered steel, a minimum of 12 inches (300 mm) **OR** 15 inches (380 mm), **as directed**, long.
c. Accessories: Standard tapered ends, corners, and splicers.
d. Finish: Standard paint **OR** Zinc coated **OR** Unfinished, **as directed**.
e. Paint Color: Black **OR** Green **OR** Brown, **as directed**.

3. Aluminum Edging: Standard-profile extruded-aluminum edging, ASTM B 221 (ASTM B 221M), Alloy 6063-T6, fabricated in standard lengths with interlocking sections with loops stamped from face of sections to receive stakes.
a. Edging Size: 3/16 inch (4.8 mm) wide by 5-1/2 inches (140 mm) deep **OR** 3/16 inch (4.8 mm) wide by 4 inches (100 mm) deep **OR** 1/8 inch (3.2 mm) wide by 5-1/2 inches (140 mm) deep **OR** 1/8 inch (3.2 mm) wide by 4 inches (100 mm) deep, **as directed**.
b. Stakes: Aluminum, ASTM B 221 (ASTM B 221M), Alloy 6061-T6, approximately 1-1/2 inches (38 mm) wide by 12 inches (300 mm) long.
c. Finish: Manufacturer's standard paint **OR** Powder-coat paint **OR** Mill (natural aluminum) **OR** Black anodized, **as directed**.
d. Paint Color: Black **OR** Green **OR** Brown, **as directed**.

4. Plastic Edging: Standard black polyethylene or vinyl edging, V-lipped bottom **OR** horizontally grooved, **as directed**, extruded in standard lengths, with 9-inch (225-mm) steel angle **OR** plastic, **as directed**, stakes.
   a. Edging Size: 0.1 inch (2.5 mm) wide by 5 inches (125 mm) deep **OR** 0.07 inch (1.8 mm) wide by 5 inches (125 mm) deep, **as directed**.
   b. Top Profile: Straight, with top 2 inches (50 mm) being 1/4 inch (6.4 mm) thick.
   c. Top Profile: Round top, 1/2 inch (13 mm) **OR** 1 inch (25 mm), **as directed**, in diameter.
   d. Accessories: Manufacturer's standard alignment clips or plugs.

K. Tree Grates
1. Tree Grates and Frames: ASTM A 48/A 48M, Class 35 (Class 250) or better, gray-iron castings of shape, pattern, and size indicated.
   OR
   Tree Grates and Frames: ASTM A 48/A 48M, Class 35 (Class 250) or better, gray-iron castings and ASTM A 36/A 36M steel-angle frames of shape, pattern, and size indicated; steel frames hot-dip galvanized.
2. Shape and Size: As indicated **OR** Round, 36 inches (914 mm) in diameter **OR** Round, 72 inches (1828 mm) in diameter **OR** 48 inches (1219 mm) square **OR** 60 inches (1524 mm) square **OR** Rectangular, 36 by 60 inches (914 by 1524 mm) **OR** Rectangular, 48 by 72 inches (1219 by 1828 mm), **as directed**.
3. Finish: As fabricated **OR** Powder-coat finish, **as directed**.
   a. Color: Low-gloss black **OR** dark brown **OR** dark green **OR** dark gray, **as directed**.

L. Miscellaneous Products
1. Wood Pressure-Preservative Treatment: AWPA C2, with waterborne preservative for soil and freshwater use, acceptable to authorities having jurisdiction, and containing no arsenic; including ammoniacal copper arsenate, ammoniacal copper zinc arsenate, and chromated copper arsenate.
2. Root Barrier: Black, molded, modular panels manufactured with 50 percent recycled polyethylene plastic with ultraviolet inhibitors, 85 mils (2.2 mm) thick, with vertical root deflecting ribs protruding 3/4 inch (19 mm) out from panel, and each panel 18 inches (457 mm) **OR** 24 inches (610 mm), **as directed**, wide.
3. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.
4. Burlap: Non-synthetic, biodegradable.
5. Planter Drainage Gravel: Washed, sound crushed stone or gravel complying with ASTM D 448 for Size No. 8.
6. Planter Filter Fabric: Woven **OR** Nonwoven, **as directed**, geotextile manufactured for separation applications and made of polypropylene, polyolefin, or polyester fibers or combination of them.
7. Mycorrhizal Fungi: Dry, granular inoculant containing at least 5300 spores per lb (0.45 kg) of vesicular-arbuscular mycorrhizal fungi and 95 million spores per lb (0.45 kg) of ectomycorrhizal fungi, 33 percent hydrogel, and a maximum of 5.5 percent inert material.

1.3 EXECUTION

A. Preparation
1. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.
2. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.
3. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.

4. Lay out plants at locations directed by Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.
5. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during digging, handling, and transportation.
   a. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after planting.
6. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.

B. Planting Area Establishment
1. Loosen subgrade of planting areas to a minimum depth of 4 inches (100 mm) **OR** 6 inches (150 mm) **OR** 8 inches (200 mm) **OR** 12 inches (300 mm), **as directed**. Remove stones larger than 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off the Owner's property.
   a. Apply superphosphate fertilizer directly to subgrade before loosening.
   b. Thoroughly blend planting soil off-site before spreading or spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil.
      1) Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
      2) Mix lime with dry soil before mixing fertilizer.
   c. Spread planting soil to a depth of 4 inches (100 mm) **OR** 6 inches (150 mm) **OR** 8 inches (200 mm) **OR** 12 inches (300 mm), **as directed**, but not less than required to meet finish grades after natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
      1) Spread approximately one-half the thickness of planting soil over loosened subgrade. Mix thoroughly into top 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**, of subgrade. Spread remainder of planting soil.
2. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.
3. Before planting, obtain the Owner's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.
4. Application of Mycorrhizal Fungi: At time directed by the Owner, broadcast dry product uniformly over prepared soil at application rate indicated on Drawings.

C. Excavation For Trees And Shrubs
1. Planting Pits and Trenches: Excavate circular planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are not acceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.
   a. Excavate approximately three times as wide as ball diameter for balled and burlapped **OR** balled and potted **OR** container-grown **OR** fabric bag-grown, **as directed**, stock.
   b. Excavate at least 12 inches (300 mm) wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
   c. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
   d. If area under the plant was initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
   e. Maintain required angles of repose of adjacent materials as shown on the Drawings. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
   f. Maintain supervision of excavations during working hours.
   g. Keep excavations covered or otherwise protected overnight **OR** after working hours **OR** when unattended by Installer's personnel, **as directed**.

h. If drain tile is shown on Drawings or required under planting areas, excavate to top of porous backfill over tile.

2. Subsoil and topsoil removed from excavations may **OR** may not, **as directed**, be used as planting soil.
3. Obstructions: Notify the Owner if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.
   a. Hardpan Layer: Drill 6-inch- (150-mm-) diameter holes, 24 inches (600 mm) apart, into free-draining strata or to a depth of 10 feet (3 m), whichever is less, and backfill with free-draining material.
4. Drainage: Notify the Owner if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.
5. Fill excavations with water and allow to percolate away before positioning trees and shrubs.

D. Tree, Shrub, And Vine Planting
1. Before planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.
2. Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.
3. Set balled and burlapped stock plumb and in center of planting pit or trench with root flare 1 inch (25 mm) above **OR** 2 inches (50 mm) above, **as directed**, adjacent finish grades.
   a. Use planting soil for backfill.
   b. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
   c. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
   d. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended in soil reports from soil-testing laboratory. Place tablets beside the root ball about 1 inch (25 mm) from root tips; do not place tablets in bottom of the hole.
   e. Continue backfilling process. Water again after placing and tamping final layer of soil.
4. Set balled and potted **OR** container-grown, **as directed**, stock plumb and in center of planting pit or trench with root flare 1 inch (25 mm) above **OR** 2 inches (50 mm) above, **as directed**, adjacent finish grades.
   a. Use planting soil for backfill.
   b. Carefully remove root ball from container without damaging root ball or plant.
   c. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
   d. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended in soil reports from soil-testing laboratory. Place tablets beside the root ball about 1 inch (25 mm) from root tips; do not place tablets in bottom of the hole.
   e. Continue backfilling process. Water again after placing and tamping final layer of soil.
5. Set fabric bag-grown stock plumb and in center of planting pit or trench with root flare 1 inch (25 mm) above **OR** 2 inches (50 mm) above, **as directed**, adjacent finish grades.
   a. Use planting soil for backfill.
   b. Carefully remove root ball from fabric bag without damaging root ball or plant. Do not use planting stock if root ball is cracked or broken before or during planting operation.
   c. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.

d. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended in soil reports from soil-testing laboratory. Place tablets beside the root ball about 1 inch (25 mm) from root tips; do not place tablets in bottom of the hole.
e. Continue backfilling process. Water again after placing and tamping final layer of soil.
f. Set and support bare-root stock in center of planting pit or trench with root flare 1 inch (25 mm) above **OR** 2 inches (50 mm) above, **as directed**, adjacent finish grade.

6. Use planting soil for backfill.
   a. Spread roots without tangling or turning toward surface, and carefully work backfill around roots by hand. Puddle with water until backfill layers are completely saturated. Plumb before backfilling, and maintain plumb while working backfill around roots and placing layers above roots.
   b. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended in soil reports from soil-testing laboratory. Place tablets beside soil-covered roots about 1 inch (25 mm) from root tips; do not place tablets in bottom of the hole or touching the roots.
   c. Continue backfilling process. Water again after placing and tamping final layer of soil.
7. When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

E. Mechanized Tree Spade Planting
1. Trees shall **OR** may, **as directed**, be planted with an approved mechanized tree spade at the designated locations. Do not use tree spade to move trees larger than the maximum size allowed for a similar field-grown, balled-and-burlapped root-ball diameter according to ANSI Z60.1, or larger than the manufacturer's maximum size recommendation for the tree spade being used, whichever is smaller.
2. When extracting the tree, center the trunk within the tree spade and move tree with a solid ball of earth.
3. Cut exposed roots cleanly during transplanting operations.
4. Use the same tree spade to excavate the planting hole as was used to extract and transport the tree.
5. Plant trees as shown on Drawings, following procedures in "Tree, Shrub, and Vine Planting" Article.
6. Where possible, orient the tree in the same direction as in its original location.

F. Tree, Shrub, And Vine Pruning
1. Remove only dead, dying, or broken branches. Do not prune for shape.
2. Prune, thin, and shape trees, shrubs, and vines as directed by Architect.
3. Prune, thin, and shape trees, shrubs, and vines according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.
4. Do not apply pruning paint to wounds.

G. Tree Stabilization
1. Install trunk stabilization as follows unless otherwise indicated:
   a. Upright Staking and Tying: Stake trees of 2- through 5-inch (50- through 125-mm) caliper. Stake trees of less than 2-inch (50-mm) caliper only as required to prevent wind tip out. Use a minimum of two stakes of length required to penetrate at least 18 inches (450 mm) below bottom of backfilled excavation and to extend to the dimension shown on Drawings **OR** at least 72 inches (1830 mm) **OR** one-third of trunk height, **as directed**, above grade. Set vertical stakes and space to avoid penetrating root balls or root masses.
   b. Use two stakes for trees up to 12 feet (3.6 m) high and 2-1/2 inches (63 mm) or less in caliper; three stakes for trees less than 14 feet (4.2 m) high and up to 4 inches (100 mm) in caliper. Space stakes equally around trees.

c. Support trees with bands of flexible ties at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.
OR
Support trees with two strands of tie wire, connected to the brass grommets of tree-tie webbing at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.

2. Staking and Guying: Stake and guy trees more than 14 feet (4.2 m) in height and more than 3 inches (75 mm) in caliper unless otherwise indicated. Securely attach no fewer than three guys to stakes 30 inches (760 mm) long, driven to grade.
   a. Site-Fabricated Staking-and-Guying Method:
      1) For trees more than 6 inches (150 mm) in caliper, anchor guys to wood deadmen buried at least 36 inches (900 mm) below grade. Provide turnbuckle **OR** compression spring, **as directed**, for each guy wire and tighten securely.
      2) Support trees with bands of flexible ties at contact points with tree trunk and reaching to turnbuckle **OR** compression spring, **as directed**. Allow enough slack to avoid rigid restraint of tree.
      3) Support trees with strands of cable or multiple strands of tie wire, connected to the brass grommets of tree-tie webbing at contact points with tree trunk and reaching to turnbuckle **OR** compression spring, **as directed**. Allow enough slack to avoid rigid restraint of tree.
      4) Attach flags to each guy wire, 30 inches (760 mm) above finish grade.
      OR
      Paint turnbuckles **OR** compression springs, **as directed**, with luminescent white paint.
   b. Proprietary Staking and Guying Device: Install staking and guying system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.
3. Root-Ball Stabilization: Install at- or below-grade stabilization system to secure each new planting by the root ball unless otherwise indicated.
   a. Wood Hold-Down Method: Place vertical stakes against side of root ball and drive them into subsoil; place horizontal wood hold-down stake across top of root ball and screw at each end to one of the vertical stakes.
      1) Install stakes of length required to penetrate at least to the dimension shown on Drawings **OR** 18 inches (450 mm), **as directed**, below bottom of backfilled excavation. Saw stakes off at horizontal stake.
      2) Install screws through horizontal hold-down and penetrating at least 1 inch (25 mm) into stakes. Predrill holes if necessary to prevent splitting wood.
      3) Install second set of stakes on other side of root trunk for larger trees as indicated.
   b. Proprietary Root-Ball Stabilization Device: Install root-ball stabilization system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.
4. Palm Bracing: Install bracing system at three or more places equally spaced around perimeter of trunk to secure each palm until established unless otherwise indicated.
   a. Site-Fabricated Palm-Bracing Method:
      1) Place battens over padding and secure battens in place around trunk perimeter with at least two straps, tightened to prevent displacement. Ensure that straps do not contact trunk.
      2) Place diagonal braces and cut to length. Secure upper ends of diagonal braces with galvanized nails into battens or into nail-attached blocks on battens. Do not drive nails, screws, or other securing devices into palm trunk; do not penetrate palm trunk in any fashion. Secure lower ends of diagonal braces with stakes driven into ground to prevent outward slippage of braces.
   b. Proprietary Palm-Bracing Device: Install palm-bracing system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.

H. Root-Barrier Installation
1. Install root barrier where trees are planted within 60 inches (1500 mm) **OR** 48 inches (1200 mm), **as directed**, of paving or other hardscape elements, such as walls, curbs, and walkways unless otherwise shown on Drawings.
2. Align root barrier vertically **OR** with bottom edge angled at 20 degrees away from the paving or other hardscape element, **as directed**, and run it linearly along and adjacent to the paving or other hardscape elements to be protected from invasive roots.
3. Install root barrier continuously for a distance of 60 inches (1500 mm) in each direction from the tree trunk, for a total distance of 10 feet (3 m) per tree. If trees are spaced closer, use a single continuous piece of root barrier.
   a. Position top of root barrier flush with finish grade **OR** 1/2 inch (13 mm) above finish grade **OR** per manufacturer's recommendations, **as directed**.
   b. Overlap root barrier a minimum of 12 inches (300 mm) at joints.
   c. Do not distort or bend root barrier during construction activities.
   d. Do not install root barrier surrounding the root ball of tree.

I. Planting In Planters
1. Place a layer of drainage gravel at least 4 inches (100 mm) thick in bottom of planter. Cover bottom with filter fabric and wrap filter fabric 4 inches (100 mm) **OR** 6 inches (150 mm), **as directed**, up on all sides. Duct tape along the entire top edge of the filter fabric, to secure the filter fabric against the sides during the soil-filling process.
2. Fill planter with lightweight on-structure planting soil. Place soil in lightly compacted layers to an elevation of 1-1/2 inches (38 mm) below top of planter, allowing natural settlement.

J. Ground Cover And Plant Planting
1. Set out and space ground cover and plants other than trees, shrubs, and vines 9 inches (225 mm) apart **OR** 12 inches (300 mm) apart **OR** 18 inches (450 mm) apart **OR** 24 inches (600 mm) apart **OR** as indicated, **as directed**, in even rows with triangular spacing.
2. Use planting soil for backfill.
3. Dig holes large enough to allow spreading of roots.
4. For rooted cutting plants supplied in flats, plant each in a manner that will minimally disturb the root system but to a depth not less than two nodes.
5. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.
6. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.
7. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

K. Planting Area Mulching
1. Install weed-control barriers before mulching according to manufacturer's written instructions. Completely cover area to be mulched, overlapping edges a minimum of 6 inches (150 mm) **OR** 12 inches (300mm), **as directed**, and secure seams with galvanized pins.
2. Mulch backfilled surfaces of planting areas and other areas indicated.
   a. Trees and Tree-like Shrubs in Turf Areas: Apply organic **OR** mineral, **as directed**, mulch ring of 2-inch (50-mm) **OR** 3-inch (75-mm), **as directed**, average thickness, with 12-inch (300-mm) **OR** 24-inch (600-mm) **OR** 36-inch (900-mm), **as directed**, radius around trunks or stems. Do not place mulch within 3 inches (75 mm) **OR** 6 inches (150 mm), **as directed**, of trunks or stems.
   b. Organic Mulch in Planting Areas: Apply 2-inch (50-mm) **OR** 3-inch (75-mm), **as directed**, average thickness of organic mulch extending 12 inches (300 mm) beyond edge of individual planting pit or trench and over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within 3 inches (75 mm) **OR** 6 inches (150 mm), **as directed**, of trunks or stems.
   c. Mineral Mulch in Planting Areas: Apply 2-inch (50-mm) **OR** 3-inch (75-mm), **as directed**, average thickness of mineral mulch extending 12 inches (300 mm) beyond edge of individual planting pit or trench and over whole surface of planting area, and finish level

with adjacent finish grades. Do not place mulch within 3 inches (75 mm) **OR** 6 inches (150 mm), **as directed**, of trunks or stems.

L. Edging Installation
1. Wood Edging: Install edging where indicated. Mitre cut joints and connections at a 45 degree angle. Fasten each cut joint or connection with two galvanized nails. Anchor with wood stakes spaced up to 36 inches (900 mm) apart, driven at least 1 inch (25 mm) below top elevation of edging. Use two galvanized nails per stake to fasten edging, of length as needed to penetrate both edging and stake and provide 1/2-inch (13-mm) clinch at point. Predrill stakes if needed to avoid splitting. Replace stakes that crack or split during installation process.
2. Steel Edging: Install steel edging where indicated according to manufacturer's written instructions. Anchor with steel stakes spaced approximately 30 inches (760 mm) apart, driven below top elevation of edging.
3. Aluminum Edging: Install aluminum edging where indicated according to manufacturer's written instructions. Anchor with aluminum stakes spaced approximately 36 inches (900 mm) **OR** 48 inches (1200 mm), **as directed**, apart, driven below top elevation of edging.
4. Plastic Edging: Install plastic edging where indicated according to manufacturer's written instructions. Anchor with steel stakes spaced approximately 36 inches (900 mm) **OR** 48 inches (1200 mm), **as directed**, apart, driven through upper base grooves or V-lip of edging.
5. Shovel-Cut Edging: Separate mulched areas from turf areas, curbs, and paving with a 45-degree, 4- to 6-inch- (100- to 150-mm-) deep, shovel-cut edge as shown on Drawings.

M. Tree Grate Installation
1. Tree Grates: Set grate segments flush with adjoining surfaces as shown on Drawings. Shim from supporting substrate with soil-resistant plastic. Maintain a 3-inch- (75-mm-) minimum growth radius around base of tree; break away units of casting, if necessary, according to manufacturer's written instructions.

N. Plant Maintenance
1. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings. Spray or treat as required to keep trees and shrubs free of insects and disease.
2. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.
3. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated past management practices whenever possible to minimize the use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

O. Pesticide Application
1. Apply pesticides and other chemical products and biological control agents in accordance with authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with the Owner's operations and others in proximity to the Work. Notify the Owner before each application is performed.
2. Pre-Emergent Herbicides (Selective and Non-Selective): Apply to tree, shrub, and ground-cover areas in accordance with manufacturer's written recommendations. Do not apply to seeded areas.
3. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

P. Cleanup And Protection
1. During planting, keep adjacent paving and construction clean and work area in an orderly condition.

2. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.
3. After installation and before Final Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

Q. Disposal
1. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off the Owner's property.

END OF SECTION 32 14 09 00

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SECTION 32 14 11 00 - ASPHALT CONCRETE SIDEWALKS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of asphalt concrete sidewalks. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Asphaltic Concrete:
1. Hot-Mixed, Hot-Laid Bituminous Paving Mixtures: ASTM D 3515.
2. Plant-Mixed, Stockpiled Asphalt Cold Mixes: Asphalt Institute Manual MS-l4.

B. Bituminous Prime: ASTM D 2027, Grades MC-30 or MC-70; ASTM D 2028, Grade RC-70; or ASTM D 2026, Grade SC-70.

C. Base Course: ASTM D 2940.

D. Bituminous Tack Coat: ASTM D 977, Grades RS-1, MS-1 or SS-1h; ASTM D 2027, Grade MC-30; ASTM D 2028, Grade RC-70; ASTM D 2026, Grade SC-70; or ASTM D 2397, Grades CRS-1 or CSS-1.

E. Seal Coat: ASTM D 2027, Grade HC-250 or MC-800; or D 2028, Grade RC-250 or RC-800.

F. Slurry Coat Mixture shall be comprised of 70 percent sand or fine aggregate, 10 percent water, and 20 percent liquid or emulsified asphalt.
1. Fine Aggregate: ASTM D 1073, Grade 2.
2. Emulsified Asphalt: ASTM D 977, Grades SS-1 or SS-1h.

1.3 EXECUTION

A. Application Temperatures: Application temperatures for all asphalt materials shall comply with provisions of the Asphalt Institute publications and the applicable ASTM standards.

B. Subgrade: Construct the subgrade for walkway replacement true to grade and compact as required.

C. Base Course
1. Placing: Spread the base course material evenly upon the prepared subgrade, in a layer of such depth that when compacted the layer will be uniform and of the thickness required.
2. Compaction: Immediately following the spreading of the material, compact the base course with equipment to a density as required.

D. Surface Course
1. Placing: Apply prime coat, and allow it to cure. The placing of the mixture shall be continuous. Paint all contact surfaces of previously constructed sidewalk with a tack coat of rapid-setting liquid asphalt just before the fresh mixture is placed.

2. Forms: Set forms with the upper edge true to line and hold grade rigidly in place by stakes placed on the outside of the forms and set flush with the top edge of the forms.
3. Compaction: Immediately following the placement of the asphalt concrete mixture, compact the surface course with equipment to a density as required.
4. Backfilling: After removing the forms and debris, backfill the exposed or excavated area adjoining the sidewalk with granular material, grade, and compact to conform to the surrounding area.

E. Patching
1. For Repair Operations Involving Raveling, Heaving, Spalling, and Alligatoring: Cut asphalt concrete paving back to solid material, making cut area rectangular with vertical sides. Remove deteriorated pavement including base material if required. Replace base course, compact, and tack coat the base material and the vertical surfaces of cut area. Fill area with new asphalt concrete and compact level with existing walkway. Dust patched area with sand or mineral dust.
2. Pothole Repair: Cut rectangular hole around pothole back to solid pavement leaving straight, vertical edges. Remove loose material and water to firm base. Fill holes and compact to within 3 inches of the surface in layers not exceeding 6 inches with either base material or asphalt mixture. Apply tack coat to base material and vertical edges. On the surface layer, fill with asphalt mixture and mound to such height that when compacted the mix will be level with surrounding walkway surface. Dust patched area with sand or mineral dust.
3. Low Spot or Depression Repair: Determine limits of depression with straightedge, and mark outline with crayon. Apply tack coat, 0.05 to 0.15 gallon per square yard, to the cleaned area, and allow to cure. Spread area with asphalt concrete mix and feather edge by raking and manipulation of the material. Roll and compact area to surrounding walkway level. Recheck with straightedge. Apply a sand seal to the patched area to prevent entrance of water.
4. Polished Aggregate Repair: Clean and dry area thoroughly. Apply tack coat at a rate of 0.05 to 0.15 gallon per square yard; overlay area with new asphalt concrete mix to a minimum 1-1/2 inch thickness and feather to adjoining walkway surfaces. Roll with pneumatic or steel rollers.
5. Damaged Edging Repair: Remove damaged or deteriorated edging materials and replace.
6. Prime Coat: Prime new base course with MC-70 liquid asphalt at a rate of 0.20 to 0.30 gallon per square yard. Take care to apply to more asphalt than will penetrate into the base course during curing. Blot excess prime with sand before the surfacing material is applied.
7. Tack Coat: Surfaces and cut edges of existing asphalt concrete shall be given a tack coat of MC-70 liquid asphalt at a rate of 0.05 to 0.15 gallon per square yard. After application of the tack coat, allow time for the material to cure before surfacing and patching material is placed.
8. Seal Coat Spray Application: Walkway surfaces that are to be sealed shall receive a liquid asphalt coat applied at a rate of 0.15 to 0.20 gallon per square yard, along with a fine aggregate at a rate of 15 to 20 pounds per square yard.

F. Crack Repair: Fill cracks after drying with liquid asphalt, sand asphalt emulsion water mixture, or slurry seal. After thorough cleaning, work the mixture into cracks by broom or squeegee. Cracks 1/8 to 1/2 inch width shall be slurry sealed and filled with liquid asphalt. Dust repaired cracks with fine aggregate or mineral dust to prevent cracking. Final thickness of the slurry seal shall be 1/8 inch minimum.

END OF SECTION 32 14 11 00

SECTION 32 14 11 00a - MISCELLANEOUS SIDEWALKS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of miscellaneous sidewalks. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Aggregate shall comply with the following:
1. Surface Course Aggregates shall be well-graded, crushed stone, 3/4- to 1-1/4 inch size, consisting of clean, sound, durable particles.
2. Masonry Grout Aggregate: ASTM C 404, Size 2.

B. Base Course: Base course material shall be a granular dense-graded, high-quality compactable material.

C. Ready-Mixed Concrete: Ready-mixed concrete shall comply with ASTM C 94. The concrete shall attain a minimum compressive strength of 3,000 psi at 28 days.

D. Portland Cement Concrete: Cement shall comply with ASTM C 150.

E. Joint Filler: Masonry joint filler shall be Portland cement concrete mix with cement complying with ASTM C 150.

F. Masonry Units: Color and texture shall match the existing as nearly as is practicable.

G. Wood and Preservatives: Footboards and supports shall be 1-1/2 inch thick Number 1 dense Douglas fir or yellow pine lumber, pressure-treated with chromated copper arsenate (CCA) preservative complying with applicable ASTM Standards. Retention shall be a minimum of 0.25 pounds per cubic foot.

1.3 EXECUTION

A. Base Course Repair: Remove material in soft spots to such depth required to provide a firm foundation for surface materials and fill with granular material of a quality that will compact when moistened. Roll or tamp this material to obtain the proper density.

B. Surface Repair
1. Aggregate Walkways: Spread the surface material evenly on the base course in a layer of such depth that when compacted, the layer will be uniform with a minimum thickness of 4 inches.
2. Joint Filling: Completely remove and clean the joint of all loose joint material, dirt, clay, or other foreign matter. Fill the joint flush with concrete to provide a uniform surface.
3. Wood Walkways: Secure wood members with galvanized nails, screws, bolts, or other approved fasteners to ensure tight joints.

4. Masonry Walkways: New or salvaged masonry units will be placed on a 3/4-inch mortar setting bed with mortar joints matching the existing walkway. Place the setting bed on a fresh 3-inch thick Portland cement concrete slab.

END OF SECTION 32 14 11 00a

SECTION 32 14 11 00b - PRECAST SIDEWALKS AND PAVERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of precast sidewalks and pavers. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: For each type of product indicated.
a. For stone varieties proposed for use on Project, include data on physical properties specified or required by referenced ASTM standards.
2. Stone Samples: For each color, grade, finish, and variety of stone required.

1.2 PRODUCTS

A. Precast Concrete Patio Blocks: ASTM C 936. Natural or colored, minimum 2 inches thick.

B. Exposed Aggregate or Granite: ASTM C 615 and National Building Granite Quarries Association, Inc.
1. Exposed Limestone: Limestone (Oolitic), ASTM C 568, Category II.
2. Exposed White Tumblestone Aggregate: As required to meet project requirements.

C. Stone Pavers
1. Bluestone Flagging Paver: Irregular cut, 1 inch thick.
2. White Marble, Crushed Stone: ASTM C 503 and Marble Institute of America (MIA), 3 inches thick.
3. Bluestone, Crushed Stone: 3 inches thick.
4. Natural Cleft Slate: ASTM C 629, 3/4-inch irregular cut, 1/2-inch random rectangular cut, or 1/4-inch random rectangular butted joints.

D. Granite Blocks: Blocks shall be 3 to 5 inches thick and comply with requirements of ASTM C 615 and National Building Granite Quarries Association, Inc. Sizes shall be 3-1/2 inches square; 4 to 12 inches by 3 to 5 inches; and 6 to 15 inches by 3 to 6 inches.

E. Mortar and Grout
1. Portland Cement: ASTM C 150 and the staining requirements of ASTM C 91.
2. Masonry Cement: ASTM C 91, non-staining.
3. Hydrated Lime: ASTM C 207, Type S.
4. Sand: ASTM C 144.
a. White Pointing Mortar: Natural white sand or ground white stone.
b. Colored Pointing Mortar: Marble, granite, or sound stone.

1.3 EXECUTION

A. Preparation
1. Clean stone or concrete block with clear water.
2. Ferrous Metal: Apply a heavy coat of bituminous paint on metal surfaces in contact with block.

B. Installation
1. Expansion Joints: Install continuous strips of preformed joint filler.

2. Clean sub-base and saturate with clean water.
3. Slush Coat: Apply 1/16-in. thick slush coat of cement grout over concrete sub-base about 15 minutes prior to placing setting bed.
4. Setting Bed: Mix one 94-lb. bag of cement to 3 cu. ft. of sand. Use only enough water to produce a moist surface when setting bed is ready for setting of stone. Spread and screed to a uniform thickness.
5. Set stone or concrete block before initial set of cement bed occurs. Wet stone or block thoroughly before setting. Apply a thin layer of neat cement paste 1/32-in. to 1/l6-in. thick to setting bed, or bottom of stone or block.
6. Grout joints as soon as possible after initial set of setting bed and tool slightly concave. Use grout mix of one bag Portland cement to 2 cu. ft. sand. Cure grout by maintaining in a moist condition for 7 days. Do not permit traffic on surface during setting of units or for at least 24 hours after final grouting of joints.

END OF SECTION 32 14 11 00b

Task	Specification	Specification Description
32 14 11 00	31 25 14 23	Unit Pavers
32 14 13 19	03 31 13 00	Cement Concrete Pavement
32 14 16 00	32 14 11 00	Asphalt Concrete Sidewalks
32 14 16 00	32 14 11 00a	Miscellaneous Sidewalks
32 14 16 00	32 14 11 00b	Precast Sidewalks And Pavers
32 14 16 00	31 25 14 23	Unit Pavers

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SECTION 32 14 33 13 - POROUS UNIT PAVING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for porous unit paving. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Porous paving consisting of concrete pavers set in aggregate setting beds.
b. Edge restraints.
c. Cast-in-place concrete edge restraints.
d. Precast concrete curbs.
e. Granite curbs.

C. Submittals
1. Product Data: For materials other than aggregates.
2. Sieve Analyses: For aggregate materials, according to ASTM C 136.
3. Samples:
a. Full-size units of each type of unit paver indicated.
b. Exposed edge restraints.
c. Precast concrete curbs.
d. Granite curbs.
e. Aggregate fill.
4. Material Certificates: For unit pavers. Include statements of material properties indicating compliance with requirements, including compliance with standards. Provide for each type and size of unit.

D. Quality Assurance
1. Preinstallation Conference: Conduct conference at Project site.

E. Delivery, Storage, And Handling
1. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.
2. Store aggregates where grading and other required characteristics can be maintained and contamination can be avoided.

1.2 PRODUCTS

A. Concrete Unit Pavers
1. Concrete Grid Pavers: Grid paving units complying with ASTM C 1319, made from normal-weight aggregates.
2. Solid Concrete Pavers for Porous Paving: Solid interlocking paving units of shapes that provide openings between units, complying with ASTM C 936, resistant to freezing and thawing when tested according to ASTM C 67, **as directed**, and made from normal-weight aggregates.
a. Thickness: 2-3/8 inches (60 mm) **OR** 3-1/8 inches (80 mm) **OR** 3-1/2 inches (90 mm) **OR** 4 inches (100 mm), **as directed**.
b. Face Size and Shape: As indicated.
c. Color: As indicated by manufacturer's designations **OR** Match the Owner's sample **OR** As selected by the Owner from manufacturer's full range, **as directed**.

B. Accessories
1. Plastic Edge Restraints: Triangular PVC extrusions, 1-3/4 inches (45 mm) high by 3-1/2 inches (90mm) wide **OR** 3-1/8 inches (80 mm) high by 9-1/2 inches (240 mm) wide, **as directed**, designed to serve as edge restraints for unit pavers; rigid type for straight edges and flexible type for curved edges, with pipe connectors and 3/8-inch- (9.5-mm-) diameter by 12-inch- (300-mm-) long steel spikes.
2. Steel Edge Restraints: Painted steel edging, 3/16 inch (4.8 mm) thick by 4 inches (100 mm) high **OR** 1/4 inch (6.4 mm) thick by 5 inches (125 mm) high, **as directed**, with loops pressed from or welded to face to receive stakes at 36 inches (900 mm) o.c., and with steel stakes 15 inches (380 mm) long for each loop.
   a. Color: As indicated by manufacturer's designations **OR** Match the Owner's sample **OR** As selected by the Owner from manufacturer's full range, **as directed**.
3. Aluminum Edge Restraints: Straight, 1/8-inch- (3.2-mm-) thick by 4-inch- (100-mm-) high **OR** Straight, 3/16-inch- (4.8-mm-) thick by 4-inch- (100-mm-) high **OR** L-shaped, 1/8-inch- (3.2-mm-) thick by 1-3/8-inch- (35-mm-) high **OR** L-shaped, 3/16-inch- (4.8-mm-) thick by 2-1/4-inch- (57-mm-) high, **as directed**, extruded-aluminum edging, with loops pressed from face to receive stakes at 12 inches (300 mm) o.c., and with aluminum stakes 12 inches (300 mm) long for each loop.
4. Precast Concrete Curbs: Made from normal-weight concrete with a compressive strength not less than 5000 psi (35 MPa) **OR** 6000 psi (41 MPa), **as directed**, and water absorption not more than 5 percent, in shapes and sizes indicated.
   a. Color and Texture: As indicated by manufacturer's designations **OR** Match the Owner's sample **OR** As selected by the Owner from manufacturer's full range, **as directed**.
5. Granite Curbs: Granite curbing, with face battered 1 inch per foot (1:12), produced in random lengths not less than 36 inches (900 mm) from granite complying with ASTM C 615.
   a. Granite Color and Grain: Light gray **OR** Dark gray **OR** Buff **OR** White **OR** Black **OR** Pink, **as directed**, with fine **OR** medium **OR** coarse, **as directed**, grain.
   b. Top Width: 4 inches (100 mm) **OR** 5 inches (125 mm) **OR** 6 inches (150 mm), **as directed**.
   c. Face Height: 4 inches (100 mm) **OR** 6 inches (150 mm) **OR** 8 inches (200 mm), **as directed**.
   d. Total Height: 12 inches (300 mm) **OR** 16 inches (400 mm) **OR** 18 inches (450 mm), **as directed**.
   e. Top Finish: Sawed **OR** Thermal **OR** Bushhammered, **as directed**.
   f. Face Finish: Split **OR** Sawed **OR** Thermal **OR** Bushhammered, **as directed**.

C. Aggregate Setting-Bed Materials
1. Graded Aggregate for Subbase: Sound crushed stone or gravel complying with ASTM D 448 for Size No. 57 **OR** ASTM D 448 for Size No. 5 **OR** ASTM D 2940, subbase material **OR** requirements in Division 31 Section "Earth Moving" for subbase material, **as directed**.
2. Graded Aggregate for Base Course: Sound crushed stone or gravel complying with ASTM D 448 for Size No. 8 **OR** ASTM D 448 for Size No. 57 **OR** ASTM D 2940, base-course material **OR** requirements in Division 31 Section "Earth Moving" for base-course material, **as directed**.
3. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33 for fine aggregate.
4. Soil Mix for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33 for fine aggregate blended with planting soil mix complying with requirements in Division 32 Section(s) "Turf And Grasses" OR "Plants", **as directed**. Use blend consisting of 1/2 sand and 1/2 soil mix **OR** 2/3 sand and 1/3 soil mix, **as directed**.
5. Graded Aggregate for Leveling Course: Sound crushed stone or gravel complying with ASTM D 448 for Size No. 8 **OR** 9, **as directed**.
6. Soil for Porous Paver Fill: Planting soil mix complying with requirements in Division 32 Section(s) "Turf And Grasses" OR "Plants", **as directed**.

7. Graded Aggregate for Porous Paver Fill: Sound crushed stone or gravel complying with ASTM D 448 for Size No. 8 **OR** 9, **as directed**.
   a. Provide stone of color indicated **OR** to match the Owner's sample, **as directed**.
8. Grass Seed: Comply with requirements in Division 32 Section "Turf And Grasses".
9. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications; made from polyolefins or polyesters, with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
   a. Survivability: Class 2; AASHTO M 288.
   b. Apparent Opening Size: No. 60 (0.250-mm) sieve, maximum; ASTM D 4751.
   c. Permittivity: 0.02 per second, minimum; ASTM D 4491.
   d. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.
10. Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
    a. Survivability: Class 2; AASHTO M 288.
    b. Apparent Opening Size: No. 40 (0.425-mm) sieve, maximum; ASTM D 4751.
    c. Permittivity: 0.5 per second, minimum; ASTM D 4491.
    d. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

1.3 EXECUTION

A. Preparation
1. Proof-roll prepared subgrade according to requirements in Division 31 Section "Earth Moving" to identify soft pockets and areas of excess yielding. Proceed with porous paver installation only after deficient subgrades have been corrected and are ready to receive subbase and base **OR** base, **as directed**, course for porous paving.

B. Installation, General
1. Do not use unit pavers with chips, cracks, voids, discolorations, and other defects that might be structurally unsound or visible in finished work.
2. Cut unit pavers with motor-driven masonry saw equipment or a block splitter, **as directed**, to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.
3. Tolerances:
   a. Variation in Plane between Adjacent Units (Lipping): Do not exceed 1/16-inch (1.5-mm) unit-to-unit offset from flush.
   b. Variation from Level or Indicated Slope: Do not exceed 1/8 inch in 24 inches (3 mm in 600 mm) and 1/4 inch in 10 feet (6 mm in 3 m) or a maximum of 1/2 inch (13 mm).
4. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.
   a. Install edge restraints to comply with manufacturer's written instructions. Install stakes at intervals required to hold edge restraints in place during and after porous paver installation.
   b. For metal edge restraints with top edge exposed, drive stakes at least 1 inch (25 mm) below top edge.
   c. Install job-built concrete edge restraints to comply with requirements in Division 32 Section "Concrete Paving".
5. Provide curbs as indicated. Install curbs before placing unit pavers.
   a. Install precast concrete **OR** granite, **as directed**, curbs on a bedding of compacted base-course material over compacted subgrade. Install curbs before placing base course for pavers. Set curbs at elevations indicated, accurately aligned, and place and compact base-course material behind curbs as indicated.
   b. Install precast concrete curbs on aggregate base course after placing and compacting base course for pavers. Set curbs with top edge 1 inch (25 mm) below top of pavers. Anchor curbs with metal stakes driven through holes in curbs into base-course material.

c. Install precast concrete curbs on aggregate-base course after placing and compacting base course for pavers. Set curbs with top surface 1/2 inch (13 mm) **OR** 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**, above top of pavers. Anchor curbs with metal stakes driven behind curbs into base-course material.

C. Setting-Bed Installation

1. Compact soil subgrade uniformly to at least 95 percent of ASTM D 698 **OR** ASTM D 1557, **as directed**, laboratory density.
2. Proof-roll prepared subgrade to identify soft pockets and areas of excess yielding. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by the Owner, and replace with compacted backfill or fill as directed.
3. Place separation **OR** drainage, **as directed**, geotextile over prepared subgrade, overlapping ends and edges at least 12 inches (300 mm).
4. For light-traffic uses, place aggregate subbase **OR** subbase and base, **as directed**, compact by tamping with plate vibrator, and screed to depth indicated.
5. For heavy-duty applications, place aggregate subbase **OR** subbase and base, **as directed**, compact to 100 percent of ASTM D 1557 maximum laboratory density, and screed to depth indicated.
6. Place drainage geotextile over compacted subbase, overlapping ends and edges at least 12 inches (300 mm).
7. Place drainage geotextile over compacted base course, overlapping ends and edges at least 12 inches (300 mm).
8. Place leveling course and screed to a thickness of 1 to 1-1/2 inches (25 to 38 mm) **OR** 2 to 2-1/2 inches (50 to 64 mm) **OR** 3 inches (76 mm), **as directed**, taking care that moisture content remains constant and density is loose and constant until pavers are set and compacted.

D. Paver Installation

1. Set unit pavers on leveling course, being careful not to disturb leveling base. If pavers have lugs or spacer bars to control spacing, place pavers hand tight against lugs or spacer bars. If pavers do not have lugs or spacer bars, place pavers with a 1/16-inch- (1.6-mm-) minimum and 1/8-inch- (3.2-mm-) maximum joint width. Use string lines to keep straight lines. Fill gaps between units that exceed 3/8 inch (10 mm) with pieces cut to fit from full-size pavers.
   a. When installation is performed with mechanical equipment, use only unit pavers with lugs or spacer bars on sides of each unit.
2. Compact pavers into leveling course with a low-amplitude plate vibrator capable of a 3500- to 5000-lbf (16- to 22-kN) compaction force at 80 to 90 Hz. Use vibrator with neoprene mat on face of plate or other means as needed to prevent cracking and chipping of pavers. Perform at least three passes across paving with vibrator.
   a. Compact pavers when there is sufficient surface to accommodate operation of vibrator, leaving at least 36 inches (900 mm) of uncompacted pavers adjacent to temporary edges.
   b. Before ending each day's work, compact installed concrete pavers except for 36-inch (900 mm) width of uncompacted pavers adjacent to temporary edges (laying faces).
   c. As work progresses to perimeter of installation, compact installed pavers that are adjacent to permanent edges unless they are within 36 inches (90 mm) of laying face.
   d. Before ending each day's work and when rain interrupts work, cover pavers that have not been compacted and leveling course on which pavers have not been placed with nonstaining plastic sheets to protect them from rain.
3. Place soil fill as follows, immediately after vibrating pavers into leveling course. Spread and screed soil fill level with tops of pavers. Vibrate pavers and add soil fill until porous paving is filled to about 3/4 inch (19 mm) from top surface; remove excess soil fill if any.
   a. Before ending each day's work, place soil fill in installed porous paving except for 42-inch (1067-mm) width of unfilled paving adjacent to temporary edges (laying faces).
   b. As work progresses to perimeter of installation, place soil fill in installed paving that is adjacent to permanent edges unless it is within 42 inches (1067 mm) of laying face.

c. Before ending each day's work and when rain interrupts work, cover paving that has not been filled with nonstaining plastic sheets to protect it from rain.

4. After filling pavers with soil, sow seed to comply with requirements in Division 32 Section "Turf And Grasses". except sow seed at half the rate specified for seeding lawns. Sweep seed from surfaces of pavers into voids and water with fine spray.
   a. Within 24 hours after sowing seed, spread an additional 3/16 inch (4.8 mm) of soil fill over seed and soak with water.
5. Place graded aggregate fill immediately after vibrating pavers into leveling course. Spread and screed aggregate fill level with tops of pavers.
   a. Before ending each day's work, place aggregate fill in installed porous paving except for 42-inch (1067-mm) width of unfilled paving adjacent to temporary edges (laying faces).
   b. As work progresses to perimeter of installation, place aggregate fill in installed paving that is adjacent to permanent edges unless it is within 42 inches (1067 mm) of laying face.
   c. Before ending each day's work and when rain interrupts work, cover paving that has not been filled with nonstaining plastic sheets to protect it from rain.
6. Remove and replace pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.

E. Maintenance And Protection
   1. Water newly planted grass and keep moist until grass is established. Maintain grass that is planted in paving to comply with requirements in Division 32 Section "Turf And Grasses".
   2. Erect barricades and warning signs as required to protect newly planted areas from traffic. Maintain barricades for 60 days after planting.

END OF SECTION 32 14 33 13

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Task	Specification	Specification Description
32 14 33 13	10 14 00 00	Vitrified Brick Pavement Replacement
32 15 40 00	32 11 16 16	Crushed Stone Paving
32 15 40 00	32 11 16 16a	Crushed Stone
32 15 40 00	32 11 16 16b	Select Gravel

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SECTION 32 16 13 13 - STEEL CURBS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of steel curbs. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Standard Steel Curb Sections: Noncorrosive steel sections as required to match existing.

B. Coating: Steel curb sections shall be zinc coated.

C. Joint Materials
1. Expansion Joint Fillers: ASTM D 1751 or ASTM D 1752.
2. Joint Sealers: ASTM D 1850.

D. Concrete: Concrete shall have a minimum compressive strength of 3,000 psi. The maximum size of aggregate shall be 1-1/2 inches. Concrete shall have a slump of not more than 3 inches and an air content by volume of concrete of 3 to 6 percent.

1.3 EXECUTION

A. Preparation: The subgrade shall be constructed to grade and cross section. The subgrade shall be of materials equal in bearing quality to the subgrade under the adjacent pavement and shall be compacted. The subgrade shall be maintained in a smooth, compacted condition, in conformity with the required section and established grade until the concrete is placed. The subgrade shall be in a moist condition when concrete is placed.

B. Installation
1. Steel Curb Setting: Steel curbs shall be carefully set to alignment and grade and to conform to the dimensions of the curb.
2. Concrete Placement And Finishing: Concrete shall be placed in layers not to exceed 6 inches. Concrete shall be thoroughly consolidated. Floated surfaces shall then be brushed with longitudinal strokes. The top surface of the entrance shall be finished to grade with a wood float. Expansion joints and contraction joints shall be constructed at right angles to the line of curb. Contraction joints shall be constructed by means of 1/8-inch thick separators, of a section conforming to the cross section of the curb and gutter. Contraction joints shall match joints in abutting Portland cement concrete pavement. At other pavements, construction joints shall be placed at not less than 5 feet nor greater than 15 feet apart. Expansion joints shall be formed by means of preformed expansion joint filler material cut and shaped to the cross section of curb. Expansion joints shall be provided in curb at the end of all returns. Expansion joints shall match expansion joints of abutting Portland cement concrete pavement. At other pavements, expansion joints at least 1/2 inch in width shall be provided at intervals not exceeding 45 feet. Exposed concrete surfaces shall be cured for not less than 7 days.

3. Backfilling: After curing, debris shall be removed and the area adjoining the concrete shall be backfilled, graded, and compacted.
4. Sealing Joints: Expansion joints and the top 1-inch depth of contraction joints shall be sealed with joint sealer. The joint opening shall be thoroughly cleaned before the sealing material is placed. Excess material on exposed surfaces of the concrete shall be removed immediately and exposed concrete surfaces cleaned.

END OF SECTION 32 16 13 13

Task	Specification	Specification Description
32 16 13 13	03 31 13 00	Cement Concrete Pavement
32 16 13 14	03 31 13 00	Cement Concrete Pavement
32 16 13 14	32 16 13 13	Steel Curbs
32 16 13 16	03 31 13 00	Cement Concrete Pavement
32 16 13 16	32 16 13 13	Steel Curbs
32 16 13 19	03 31 13 00	Cement Concrete Pavement
32 16 13 23	03 31 13 00	Cement Concrete Pavement
32 16 13 23	32 16 13 13	Steel Curbs
32 16 13 33	03 31 13 00	Cement Concrete Pavement
32 16 13 33	32 16 13 13	Steel Curbs
32 16 13 43	32 14 33 13	Porous Unit Paving
32 16 23 00	32 14 11 00	Asphalt Concrete Sidewalks
32 16 23 00	32 14 11 00a	Miscellaneous Sidewalks
32 16 23 00	32 14 11 00b	Precast Sidewalks And Pavers
32 16 23 00	31 25 14 23	Unit Pavers
32 16 43 00	32 01 13 61	Asphalt Paving
32 17 13 23	11 12 16 00	Parking Control Equipment
32 17 13 23	11 12 16 00a	Prefabricated Control Booths
32 17 13 26	11 12 16 00	Parking Control Equipment
32 17 13 26	11 12 16 00a	Prefabricated Control Booths
32 17 16 00	32 01 13 61	Asphalt Paving
32 17 23 13	32 01 13 61	Asphalt Paving
32 17 23 13	03 31 13 00	Cement Concrete Pavement
32 17 23 13	32 01 11 53	Traffic Coatings
32 17 23 23	32 01 13 61	Asphalt Paving
32 17 23 23	03 31 13 00	Cement Concrete Pavement
32 17 23 23	32 01 11 53	Traffic Coatings
32 17 23 33	32 01 13 61	Asphalt Paving
32 17 23 33	03 31 13 00	Cement Concrete Pavement
32 17 23 33	32 01 11 53	Traffic Coatings

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SECTION 32 17 26 00 - TACTILE/DETECTABLE WARNING TILE

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for tactile/detectable warning tile. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product data for each specified product.
2. Shop drawings, showing detailed plans of tile profile, fastener locations, and installation methods
3. Two (2) tile samples, minimum size 6” x 8” of the kind proposed for use.
4. Material Test Reports: Submit test reports from qualified independent testing laboratory indicating that materials proposed for use are in compliance with requirements and meet the properties indicated. All test reports shall be conducted on a cast-in-place tactile panel system as certified by a qualified independent testing laboratory.
5. Maintenance Instructions: Submit copies of manufacturer’s specified maintenance practices for each type of tactile tile and accessory as required.

C. Quality Control
1. Americans with Disabilities Act (ADA): Provide tactile warning surfaces, which comply with the detectable warnings on walking surfaces, section of the Americans with Disabilities Act (Title 49 CFR TRANSPORTATION, PART 37.9 STANDARDS FOR ACCESSIBLE TRANSPORTATION FACILITIES, Appendix A, Section 4.29.2 DETECTABLE WARNINGS ON WALKING SURFACES.
2. California Code of Regulations (CCR): Provide only approved DSAAC detectable warning products as provided in the California Code of Regulations (CCR). Title 24, Part 1, Articles 2, 3 and 4 and Part 2, Section 205 definition of “Detectable Warning”. Section 1127B.5 for “Curb Ramps” and Section 1133B.8.5 for “Detectable Warnings at Hazardous Vehicle Area’s”.
3. Performance: Tiles shall meet or exceed the following criteria:
   a. Water Absorption: 0.35% maximum, when tested in accordance with ASTM D570.
   b. Slip Resistance: 0.90 minimum combined wet/ dry static coefficient of friction on top of domes and field area, when tested in accordance with ASTM C1028.
   c. Compressive Strength: 18,000 psi minimum, when tested in accordance with ASTM D695.
   d. Tensile Strength: 10,000 psi minimum, when tested in accordance with ASTM D638.
   e. Flexural Strength: 24,000 psi minimum, when tested in accordance with ASTM C293.
   f. Gardner Impact: 450 inch-pounds per inch minimum, when tested in accordance with Geometry “GE” of ASTM D5420.
   g. Chemical Stain Resistance: No reaction to 1% hydrochloric acid, urine, calcium chloride, stamp pad ink, gum and red aerosol paint, when tested in accordance with ASTM D543.
   h. Wear Depth: 0.03” maximum, after 1000 abrasion cycles of 40 grit Norton Metallite sandpaper, when tested in accordance with ASTM D2486-Modified.
   i. Flame Spread: 25 maximum, when tested in accordance with ASTM E84.
   j. Accelerated Weathering: No deterioration, fading or chalking for 2000 hours, when tested in accordance with ASTM D2565.
4. Tactile warning tiles embedded in or adhered to concrete shall meet or exceed the following performance criteria:
   a. Accelerated Aging and Freeze Thaw of Adhesive System: No cracking, delamination, warping, checking, blistering, color change, loosening, etc. when tested in accordance with ASTM D1037.
   b. Salt and Spray Performance: No deterioration after 100 hours of exposure, when tested in accordance with ASTM B117.

D. Delivery, Storage And Handling
   1. Tiles shall be suitably packaged or crated to prevent damage in shipment or handling. Finished surfaces shall be protected by sturdy wrappings, and tile type shall be identified by part number.
   2. Tiles shall be delivered to location at building site for storage prior to installation.

E. Warranty
   1. Installed tiles shall be warranted for a minimum of five (5) years against failure of adhesives, fasteners and sealants.

1.2 PRODUCT

A. Materials
   1. Vitrified Polymer Composite (VPC) tiles shall be an epoxy polymer composition with an ultra violet stabilized coating employing aluminum oxide particles in the truncated domes. The tile shall incorporate an in-line dome pattern of truncated domes. For wheelchair safety the field area shall consist of a non-slip surface with a minimum of 40 - 90º raised points 0.045" high, per square inch.
   2. Color: Safety Yellow, (Federal Color # 33538) colorfast, UV stabilized coating. Color shall be homogeneous throughout the tile.

B. Cast-In-Place Tactile Tile
   1. Tile shall be minimum 1-3/8" thick, with minimum 3/8" thick face and ribs designed for after-pour embedment in concrete.

C. Surface Applied Detectable Warning Surface Tile
   1. The tile shall have with countersunk fastening holes and perimeter beveled edges.
   2. Accessories:
      a. Fasteners: Color matched, corrosion resistant, flat head drive anchor, 1/4" diameter x 1-3/4" long.
      b. Adhesive: Urethane elastomeric adhesive.
      c. Sealants: Epoxy two component sealant.

D. Modular Paver Tactile Tile
   1. Pre-cast with a 1-3/8" thick reinforced epoxy polymer concrete core.
      a. Polymer Concrete and/or epoxy resin properties shall meet or exceed the following criteria:

Tensile Strength of Resin:	greater than 7,000psi; ASTM D638
Modulus of Elasticity of Resin:	greater than 4,000psi; ASTM D638
Bond Strength of Polymeric Concrete:	greater than 8,000psi; ASTM C551

   2. Accessories:
      a. Adhesive: Urethane elastomeric adhesive.
      b. Backer Rod: ASTM C 1330, Type C (closed-cell material with a surface skin) **OR** Type O (open-cell material) **OR** Type B (bicellular material with a surface skin), **as directed**, as approved in writing by joint-sealant manufacturer for joint application indicated, and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance

E. Surface Applied Detectable Guidance Tiles
   1. Accessories:
      a. Adhesive: Heavy-duty polyurethane elastomeric adhesive.
      b. Sealants: Heavy-duty polyurethane elastomeric sealant.

F. Surface Applied Detectable Directional Bar Tiles
   1. Accessories:
      a. Fasteners: Stainless steel low profile expansion anchors, 3/16" diameter by 2" long.

b. Adhesive: Heavy-duty polyurethane elastomeric adhesive.
c. Sealants: Heavy-duty polyurethane elastomeric sealant.

1.3 EXECUTION

A. Installation
1. Installation shall be in strict compliance with manufacturer's printed instructions.

END OF SECTION 32 17 26 00

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SECTION 32 18 16 13 - PLAYGROUND SURFACE SYSTEMS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for playground surface systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
   a. Unitary synthetic seamless surface.
   b. Synthetic, dual-density tile surface.
   c. Organic loose-fill surface.
   d. Inorganic loose-fill surface.

C. Definitions
1. Critical Height: Standard measure of shock attenuation. According to CPSC No. 325, this means "the fall height below which a life-threatening head injury would not be expected to occur."
2. SBR: Styrene-butadiene rubber.

D. Performance Requirements
1. Impact Attenuation: According to ASTM F 1292.
2. Accessibility of Surface Systems: According to ASTM F 1951.
3. Minimum Characteristics for Organic Loose-Fill Surfaces: According to ASTM F 2075.

E. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: Show the following:
   a. Installation details for curbs, ramps, and accessories.
   b. Colors and pattern of surfaces.
   c. Location of wear mats in organic loose-fill surfaces.
   d. Location of drainage accessories.
3. Samples: For each type of playground surface system indicated.
   a. Minimum 1-quart (0.95-L) loose-fill surface sealed in a container.
   b. Minimum 6-by-6-inch- (150-by-150-mm-) square Sample of unitary synthetic seamless **OR** synthetic tile **OR** synthetic, dual-density, tile, **as directed,** surface.
   c. 6-inch (150-mm) long by full-size cross section of border edging.
   d. Minimum 12-by-12-inch (300-by-300-mm) Sample of geosynthetic fabric.
   e. Minimum 6-by-6-inch (150-by-150-mm) Sample of geosynthetic, molded-sheet drainage panel.
4. Qualification Data: For Installer and testing agency.
5. Material Test Reports: For the following, from a qualified testing agency, indicating compliance with requirements:
   a. Unitary synthetic seamless surface.
   b. Synthetic tile surface.
   c. Organic loose-fill surface.
   d. Inorganic loose-fill surface.
6. Material Certificates: For each playground surface system product, signed by manufacturers.
7. Field quality-control test reports.
8. Maintenance Data: For playground surface system to include in maintenance manuals.
9. Warranty: Special warranty specified in this Section.

F. Quality Assurance

1. Installer Qualifications: An employer of workers trained and approved by manufacturer.
2. Testing Agency Qualifications: An independent agency qualified according to ANSI Z34.1 for testing indicated.
3. Source Limitations: Obtain playground surface system materials, including primers and binders, through one source from a single manufacturer.
   a. Provide secondary materials including adhesives, primers, geosynthetics, and repair materials of type and from source recommended by manufacturer of playground surface system materials.

G. Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of playground surface system that fail in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
   a. Reduction in impact attenuation.
   b. Deterioration of surface and other materials beyond normal weathering.
2. Warranty Period: Three **OR** Five **OR** 10, **as directed,** years from date of Final Completion.

1.2 PRODUCTS

A. Unitary Synthetic Seamless Surface
1. Surface System: Poured-in-place, single-layer system. Provide manufacturer's standard thickness as required for overall thickness indicated, tested for impact attenuation according to ASTM F 1292 and for accessibility according to ASTM F 1951.
   a. Cushion Course: Manufacturer's standard blend of recycled SBR and EPDM rubber, particles forming an integral wearing course and cushion course, site mixed and applied.
   b. Binder: Weather-resistant, UV-stabilized, flexible, nonhardening, 100 percent solids polyurethane complying with requirements of authorities having jurisdiction for nontoxic and low VOC content.
   c. Critical Height: 3 feet (1 m) **OR** 4 feet (1.2 m) **OR** 5 feet (1.5 m) **OR** 6 feet (1.8 m) **OR** 7 feet (2.1 m) **OR** 8 feet (2.4 m) **OR** 9 feet (2.7 m) **OR** 10 feet (3 m) **OR** 12 feet (3.7 m), **as directed**.
   d. Overall Thickness: Not less than as required for critical height indicated 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 2-1/2 inches (64 mm) **OR** 3 inches (75 mm) **OR** 3-1/2 inches (89 mm) **OR** 4 inches (100 mm), **as directed**.
   e. Primer/Adhesive: Manufacturer's standard primer and weather-resistant, moisture-cured polyurethane adhesive suitable for unit, substrate, and location indicated.
   f. Color(s): As selected from manufacturer's full range.
2. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by playground surface system manufacturer.

B. Unitary Synthetic Dual-Density Seamless Surface
1. Surface System: Poured-in-place, two-layer system with wearing course over cushion course. Provide manufacturer's standard thickness for each layer as required for overall thickness indicated, tested for impact attenuation according to ASTM F 1292 and for accessibility according to ASTM F 1951.
   a. Wearing Course: Formulation of EPDM rubber particles, with minimum of 20 percent and maximum of 26 percent of ethylene propylene-diene-saturated polymethylene main chain along with other organic and inorganic components.
   b. Cushion Course: Manufacturer's standard formulation of recycled SBR particles and polyurethane, site mixed and applied.
   c. Binder: Weather-resistant, UV-stabilized, flexible, nonhardening, 100 percent solids polyurethane complying with requirements of authorities having jurisdiction for nontoxic and low VOC content.
   d. Lacquer Top Coat: Manufacturer's standard polyurethane-based formulation.

e. Critical Height: **3 feet (1 m) OR [4 feet (1.2 m) OR 5 feet (1.5 m) OR [6 feet (1.8 m) OR 7 feet (2.1 m) OR 8 feet (2.4 m) OR 9 feet (2.7 m) OR 10 feet (3 m) OR 12 feet (3.7 m), as directed.**

f. Overall Thickness: Not less than as required for critical height indicated **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 2-1/2 inches (64 mm) OR 3 inches (75 mm) OR 3-1/2 inches (89 mm) OR 4 inches (100 mm) OR 4-1/2 inches (114 mm) OR 5 inches (125 mm) OR 5-1/2 inches (140 mm), as directed**.

g. Primer/Adhesive: Manufacturer's standard primer and weather-resistant, moisture-cured polyurethane adhesive suitable for unit, substrate, and location indicated.

h. Wearing Course Color(s): As selected from manufacturer's full range.

1) Color **Pattern OR Graphics**: As directed.

2. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by playground surface system manufacturer.

C. Unitary Synthetic Tile Surface

1. Tile System: Manufacturer's standard blend of recycled SBR, EPDM rubber, or PVC particles forming an integral wearing course and cushion course, tested for impact attenuation according to ASTM F 1292 and for accessibility according to ASTM F 1951.

a. Unit Size: **24 by 24 inches (600 by 600 mm)**.

b. Base Profile: With integral ribbed or grid-patterned underside forming channels for water drainage between surface and substrate.

c. Border Edge and Corner Units: Tapered, bevel-edged units that transition from the face of playground surface to the adjacent surface below it with a straight-sloped outside edge; size compatible with field units maintaining layout pattern continuity. Provide border edge and corner units where surface does not abut vertical surfaces.

d. Critical Height: **7 feet (2.1 m) OR 12 feet (3.7 m),** as directed.

e. Overall Thickness: Not less than as required for critical height indicated **1-3/4 inches (45 mm) OR 2-3/4 inches (70 mm) OR 4 inches (100 mm), as directed**.

f. Anchors: Manufacturer's standard.

g. Anchor Cement: Manufacturer's standard nonshrink grout or polymer resin.

h. Tile Color(s): **As directed**.

1) Color Pattern **OR** Graphics: As selected from manufacturer's full range.

i. Filler/Sealant: Manufacturer's standard clear silicone or polyurethane filler/sealant suitable for exterior use.

2. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by playground surface system manufacturer.

D. Organic Loose-Fill Surface

1. Wood Chips: Random-sized wood chips suitable for mulching trees and shrubs.

2. Double-Shredded Bark Mulch: Random-sized bark, shredded twice, suitable for mulching trees and shrubs.

3. Engineered Wood Fibers: Random-sized wood fibers, in manufacturer's standard fiber size, approximately 10 times longer than wide; containing no bark, leaves, twigs, or foreign or toxic materials according to ASTM F 2075; graded according to manufacturer's standard specification for material consistency for playground surfaces and for accessibility according to ASTM F 1951.

a. Critical Height: 6 feet (1.8 m) **OR** 9 feet (2.7 m) **OR** 10 feet (3 m) **OR** 11 feet (3.4 m), **as directed**.

b. Uncompressed Material Depth: Not less than as required for critical height indicated **OR** 6 inches (150 mm) **OR** 9 inches (229 mm) **OR** 12 inches (305 mm), **as directed**.

E. Inorganic Loose-Fill Surface

1. Inorganic Aggregate Materials: Clean, washed, and free of loam, clay, organic matter, debris, and other foreign substances.

a. Fine Sand: Complying with ASTM C 136 for the following sieve analysis test results; provide minimum depth of material with critical height indicated according to CPSC No. 325:

1) Sieve Sizes and Percent Passing through Screen: No. 16 passing 100 percent, No. 30 passing 98 percent, No. 50 passing 62 percent, No. 100 passing 17 percent, and No. 200 passing 0 to 1 percent.

b. Coarse Sand: Complying with ASTM C 136 for the following sieve analysis test results; provide minimum depth of material with critical height indicated according to CPSC No. 325:
1) Sieve Sizes and Percent Passing through Screen: No. 4 passing 98 percent, No. 8 passing 73 percent, No. 16 passing 4 percent, No. 30 passing 1 percent, and No. 50 passing 0 to 1 percent.

c. Fine Gravel: Rounded, hard, durable stone, free of sand, with particle size less than 3/8 inch (9.5 mm) in diameter complying with ASTM C 136 for the following sieve analysis test results; provide minimum depth of material with critical height indicated according to CPSC No. 325:
1) Sieve Sizes and Percent Passing through Screen: 3/8 inch (9.5 mm) passing 100 percent, No. 3-1/2 passing 93 percent, No. 4 passing 65 percent, No. 8 passing 8 percent, No. 16 passing 5 percent, and No. 30 passing 4 percent.

d. Medium Gravel: Rounded, hard, durable, riverbed gravel or tumbled stone, free of sand, with particle size less than 1/2 inch (13 mm) in diameter complying with ASTM C 136 for the following sieve analysis test results; provide minimum depth of material with critical height indicated according to CPSC No. 325:
1) Sieve Sizes and Percent Passing through Screen: 1/2 inch (13 mm) passing 100 percent, 3/8 inch (9.5 mm) passing 80 percent, 5/16 inch (8 mm) passing 20 percent, No. 4 passing 8 percent, and No. 16 passing 3 percent.

2. Shredded Tires: Rubber particles from 100 percent recycled tires, free from steel wires, rubber dust, and other foreign substances, tested for impact attenuation according to ASTM F 1292 and for accessibility according to ASTM F 1951.
a. Critical Height: 6 feet (1.8 m) **OR** 9 feet (2.7 m) **OR** 10 feet (3 m) **OR** 11 feet (3.4 m), **as directed**.
b. Uncompressed Material Depth: Not less than as required for critical height indicated **OR** 6 inches (150 mm) **OR** 9 inches (229 mm) **OR** 12 inches (305 mm), **as directed**.

F. Loose-Fill Accessories
1. Edgings: Anchored-in-place, weather-resistant containment barrier designed to minimize sharp edges, protrusions, and tripping hazards; formed by interconnected, modular units.
a. Polyethylene Units: UV-light-stabilized, 100 percent recycled polyethylene, not less than 1/4-inch (6-mm) wall thickness; made into smooth-surfaced straight and curved units with radiused exposed edges and integral, molded-in color; in manufacturer's standard sizes.
1) Color: As selected from manufacturer's full range.
b. Metal Units: Steel fabricated with radiused exposed edges and finished with PVC plastisol coating, straight **OR** right-angled corner, **as directed,** and curved units, in manufacturer's standard sizes.
1) Color: As selected from manufacturer's full range.
c. Rubber Units: Compression molded from 100 percent recycled SBR, in manufacturer's standard sizes.
1) Color: As selected from manufacturer's full range.
d. Anchor Stakes: Manufacturer's standard, of corrosion-resistant-coated metal or noncorrodible material, designed to be nonprotruding when installed, for connecting units and securing in-place.
2. Stabilizing Mats: Manufacturer's standard, water-permeable PVC or rubber mats tested for impact attenuation according to ASTM F 1292, and rated for use in the following locations, with anchoring system designed to anchor mat securely to subgrade through engineered wood:
a. Location: At excessive wear areas and as follows:
1) On top of loose-fill surface.
2) Below top of loose-fill surface.
3) On subgrade below loose-fill surface.

4) Under and in front of slide exits.
5) Under and around swings.
6) At finished grade around transfer stations at accessible perimeter.
7) At high-traffic areas and playground equipment where indicated.
8) Where indicated.

b. Size: 36 by 36 inches (914 by 914 mm) **OR** 40 by 40 inches (1016 by 1016 mm) **OR** 48 by 48 inches (1200 by 1200 mm), **as directed**.

c. Color: As selected from manufacturer's full range.

G. Geosynthetics

1. Drainage/Separation Geotextile: Nonwoven, needle-punched geotextile, manufactured for subsurface drainage applications and made from polyolefins or polyesters; complying with the following minimum properties determined according to ASTM D 4759 and referenced standard test methods:
   a. Weight: 4 oz./sq. yd. (136 g/sq. m) according to ASTM D 5261.
   b. Water Flow Rate: 100 gpm/sq. ft. (68 L/s per sq. m) **OR** 150 gpm/sq. ft. (102 L/s per sq. m), **as directed,** according to ASTM D 4491.
2. Molded-Sheet Drainage Panel: Prefabricated, composite drainage panels made with drainage core and filter fabric.
   a. Drainage Core: Three-dimensional, nonbiodegradable, molded-plastic-sheet material designed to effectively drain water under maximum fill pressures.
   b. Fabric: Nonwoven, needle-punched geotextile, specifically manufactured as a filter geotextile and made from polyolefins or polyesters; complying with the following minimum properties determined according to ASTM D 4759 and referenced standard test methods:
      1) Weight: 4 oz./sq. yd. (136 g/sq. m) according to ASTM D 5261.
      2) Water Flow Rate: 100 gpm/sq. ft. (68 L/s per sq. m) **OR** 150 gpm/sq. ft. (102 L/s per sq. m), **as directed,** according to ASTM D 4491.
   c. Minimum Flow Rate: 9 gpm/foot (1.9 L/s per m) according to ASTM D 4491.
3. Weed-Control Barrier: Composite fabric geotextile consisting of woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, weighing not less than 4.8 oz./sq. yd. (160 g/sq. m).

1.3 EXECUTION

A. Preparation

1. General: Prepare substrates to receive surfacing products according to playground surface system manufacturer's written instructions. Verify that substrates are sound and without high spots, ridges, holes, and depressions.
2. Concrete **OR** Asphalt, **as directed,** Substrates: Provide sound surface free of laitance, efflorescence, curing compounds, and other contaminants incompatible with playground surface system.
   a. Repair unsatisfactory surfaces and fill holes and depressions.
   b. Mechanically scarify or otherwise prepare concrete substrates to achieve recommended degree of roughness.
   c. Saw cut concrete **OR** asphalt, **as directed,** for terminal edges of playground surface systems as indicated.
   d. Treat control joints and other nonmoving substrate cracks to prevent telegraphing through playground surface system.

B. Installation, General

1. General: Comply with playground surface system manufacturer's written installation instructions. Install playground surface system over area and in thickness indicated.

C. Geosynthetic Installation

1. General: Install geosynthetics according to playground surface system manufacturer's and geosynthetic manufacturer's written instructions.
   a. Geotextiles: Completely cover area indicated, overlapping sides and edges a minimum of 4 inches (100 mm) **OR** 8 inches (200 mm), **as directed,** with manufacturer's standard treatment for **OR** overlapping loosely laid **OR** adhesively bonded, **as directed,** seams.
      1) Perimeter: Adhere edges on all sides to top of perimeter curb or footing.

D. Installation Of Seamless Playground Surface Systems
   1. Seamless Surface: Mix and apply components of playground surface system according to manufacturer's written instructions.
      a. Substrate Primer: Apply over prepared substrate at manufacturer's standard spreading rate for type of substrate.
      b. Cushion Course: Spread evenly over primed substrate to form a uniform layer applied at manufacturer's standard spreading rate in one continuous operation, with a minimum of cold joints.
      c. Cushion Course: Lay out tile units from center marks established with principal perimeter edges, discounting minor offsets, so units at opposite edges of installation are of equal width. Adjust as necessary to avoid using cut widths that equal less than one-half of a unit at perimeter.
      d. Intercoat Primer: Over cured cushion course, apply primer at manufacturer's standard spreading rate.
      e. Wearing Course: Spread over primed base course to form a uniform layer applied at manufacturer's standard spreading rate in one continuous operation and, except where color changes, with no **OR** a minimum of, **as directed,** cold joints. Finish surface to produce manufacturer's standard wearing-surface texture.
         1) Where colored pattern is **OR** graphics are, **as directed,** indicated, place adjacent colored material as soon as placed colored material is sufficiently cured, using primer or adhesive if required by manufacturer's written instructions.
      f. Edge Treatment: Flush **OR** Extended surface course **OR** Saw-cut base and vertical pour, **as directed**.

E. Installation Of Tile Playground Surface Systems
   1. Tile Units: Provide a uniform wearing surface with no unaligned units, raised edges, or surface imperfections.
      a. Lay out units from center marks established with principal perimeter edges, discounting minor offsets, so units at opposite edges of installation are of equal width. Adjust as necessary to avoid using cut widths that equal less than one-half of a unit at perimeter. Allow for border edge.
         1) Alignment Axis and Pattern: Lay units along axis and in grid pattern indicated.
            OR
            Alignment Axis: Lay units square **OR** at a 45-degree angle, **as directed,** with playground equipment axis.
         2) Pattern: Lay units in straight-line grid pattern with joints aligned.
            OR
            Pattern: Lay units in half-unit, offset grid pattern with staggered joints.
      b. Cut and fit units around playground equipment supports and vertical surfaces. Do not create voids greater than 3/8 inch (9.5 mm) wide.
         1) Do not stretch units during installation.
      c. Adhesively Applied Units: Adhere units to substrates using a full spread of adhesive applied to substrate or to unit and to each other.
      d. Mechanically Fastened Units: Anchor to substrates.
      e. Mechanically Attached Units (only for solid revulcanized rubber units): Mechanically attach all four sides of units, including border edge and corner units, to each other using number of fasteners per side as recommended by system manufacturer. Free lay sheet of attached units on substrate.

f. Mechanically Attached Units Retained by Adhesively Applied Perimeter Units: Mechanically attach all four sides of units to each other using number of fasteners per side as recommended by system manufacturer. Adhere not less than one course of perimeter units and border edge and corner units to substrates using a full spread of adhesive applied to substrate or to unit and to each other.
g. Edge Borders: Maintain fully cushioned thickness.
h. Filler/Sealant: Mask area surrounding cutouts around playground equipment supports and other obstructions. Apply a full bead of filler/sealant, filling cutouts immediately after laying tile with cutout.

F. Installation Of Loose-Fill Playground Surface Systems
1. Loose-Fill Edgings: Place as indicated, and permanently secure in place and attach to each other according to edging manufacturer's written instructions.
2. Loose Fill: Place playground surface system materials including manufacturer's standard amount of excess material for compacting naturally with time **OR** including manufacturer's standard amount of excess material for compacting mechanically, **as directed,** to required depths after Installation of playground equipment support posts and foundations.
3. Stabilizing Mats: Coordinate installation of mats and mat anchoring system with placing and compacting of loose-fill.
4. Compacting and Grading: Uniformly compact and grade loose-fill according to manufacturer's written instructions to an even surface free from irregular surface changes as indicated.
5. Finish Grading: Hand rake to a smooth finished surface and to required elevations.

G. Field Quality Control
1. Testing Services: Testing and inspecting of completed applications of playground surface system shall take place according to ASTM F 1292.
2. Remove and replace applications of playground surface system where test results indicate that it does not comply with requirements.
3. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with requirements.

H. Protection
1. Seamless **OR** Tile, **as directed,** Systems: Prevent traffic over system for not less than 48 hours after installation.

END OF SECTION 32 18 16 13

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SECTION 32 18 16 13a - TRACK, COURT, AND PLAYGROUND MARKINGS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing of materials and the installation of track, court, and playground markings. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Submit product data and manufacturer's recommendations for each marking to be furnished.
2. Submit sample of each marking to be furnished.
3. Submit "Line Layout Drawing" prior to installation of marking and upon completion of markings, submit three (3) certified line layout drawings indicating all lines and colors.

C. Quality Assurance: Personnel shall have a minimum of three years marking experience.

D. Delivery, Storage and Handling: Deliver paint to site in original sealed containers or drums, with labels legible, intact and unbroken. Comply with all health and fire regulations.

E. Environmental Requirements: Do not install markings on wet or frozen surfaces. Comply with manufacturer's instructions for temperature requirements.

1.2 PRODUCTS

A. Manufacturers
1. Line Paint for Resilient Surface: Aliphatic polyurethane paint, such as Hi-Build Aliphatic Polyurethane paint by Sherwin-Williams, or approved equivalent.
2. Line Paint for Asphaltic Concrete Pavement: Latex traffic marking paint, such as Setfast Latex Traffic Marking paint by Sherwin-Williams, or approved equivalent.
3. Line Paint for Athletic Wearing Surface (Plexipave): 100% acrylic latex paint, such as Plexicolor by California Products, or approved equivalent.

1.3 EXECUTION

A. Application
1. Line Painting
   a. Accurately measure and layout line markings.
   b. Apply paint with mechanical equipment.
   c. Paint lines as specified below under "Track Marking".
   d. Provide uniform straight edges.
   e. Apply not less than two coats in accordance with manufacturer's recommended rates.
   f. Lines shall be 2 in. (50 mm) wide unless otherwise specified.
2. Track Marking
   a. Employ a licensed land surveyor to accurately measure and lay out line markings in accordance with National Federation of State High School Athletic Association Regulations or other Standards set forth by the Owner.
   b. Events:
      1) 100 meter dash
      2) 200 meter dash
      3) 400 meter dash

4) 800 meter run
5) 1600 meter run
6) 3200 meter run
7) One mile run
8) 4 x 100 meter relay
9) 4 x 200 meter relay
10) 4 x 400 meter relay
11) 4 x 800 meter relay
12) 110 meter high hurdles
13) 300 meter intermediate hurdles
14) Girls 100 meter hurdles
15) Girls 300 meter hurdles

c. Hurdle location markers: yellow hash marks.
d. Lane lines: white (min. 42 in. (105 cm) apart).
e. Exchange zones:
1) 4 x100 m green
2) 4 x 200 m blue
3) 4 x 400 m yellow
4) 12 in. (305 mm) across entire lane width.
f. Lane numbers: Stenciled in three locations from inside to outside. Numbers shall be 24 in. (60 cm) high and white in color.
g. Finish line to be located near bleachers.
h. All starts and finishes to be white.

B. Cleaning: Upon completion of work, remove containers and debris and leave site in clean orderly condition acceptable to the Owner.

C. Protection
1. Erect temporary barriers to protect paint during drying period.
2. Protect markings from damage until completion of project.

END OF SECTION 32 18 16 13a

SECTION 32 18 16 13b - SYNTHETIC RUNNING TRACK SURFACE

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of synthetic running track surface. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals: Submit the following:
1. Sample of the actual sport surface in the standard color(s) selected.
2. Technical data sheets of the product.
3. Adhesive product data sheets and manufacturer's certificate indicating approval for the proposed application.
4. Line paint data sheets and the manufacturer's certificate indicating approval for the proposed application.
5. Submit 3 copies of the maintenance instruction.

C. Delivery and Storage: Deliver and store the material in the original packaging with the labels intact in a controlled environment of a minimum temperature of 55°F (13°C) and under 50% relative humidity. Protect work until accepted by the Owner.

D. Warranty: Provide manufacturer's standard warranty.

1.2 PRODUCTS

A. Acrylic Color Coating System
1. Manufacturer: Copeland Coating Company or approved equivalent.
2. System shall consist of stone base, asphalt binder/top, cushion made of granulated rubber particles suspended in acrylic emulsions **(as directed)**, acrylic filler coat(s), acrylic finish coat, and acrylic line paint.
3. Design and construction shall be by materials manufacturer.

B. Polyurethane
1. Manufacturer: Conica Sports Surfaces or approved equivalent.
2. Impermeable, full polyurethane, 3 layer athletic track system. In-situ applied with a granular colored EPDM finish. IAAF certified as required.

C. Rubber Granule Surface
1. Manufacturer: Atlas Track & Tennis or approved equivalent.
2. Rubber granules applied “dry” to the surface and adhered by spray application of a resin binder. This process is repeated until the specified thickness is achieved, allowing sufficient curing time between each application. The process is then finished with a structural spray coating of highly pigmented polyurethane coating.

D. Prefabricated Rubber Surface
1. Manufacturer: Mondo USA, or approved equivalent.
2. Prefabricated rubber sport surface to be 6 mm (1/4”) **OR** 8mm (5/16") **OR** 10mm (3/8") **OR** 12mm (1/2") **OR** 14mm (9/16"), **as directed**, thickness, with a non-slip, non-reflecting, highly spike resistant top surface. Provided in manufacturer’s standard colors.
3. Prefabricated rubber surface to be sheet goods, double durometer or homogenous vulcanized and calandered, with a particular closed cell structure, based on special isoprenic rubbers, mineral fillers, vulcanizing and stabilizing agents and color pigments, highly resistant to UV rays

and atmospherical agents, with system of differentiated elasticity between top surface and base, supplied in rolls of suitable size and thickness. Surface shall have a special texture including adhesive and striping

4. Prefabricated rubber sport surface to be manufactured in two layers, which are vulcanized together. The shore hardness of the lower layer to be less than the upper layer, shore hardness of the respected layers to be recommended by the manufacturer and within the limits hereinafter specified. Field laminated triple durometer are unacceptable.
5. Adhesive: Rubber sport surface adhesive to be two part polyurethane adhesive suitable for adherence of a sheet good to asphalt, concrete or urethane substrate. Adhesive to be supplied or approved/recommended by sport surface manufacturer.

E. Patching Compound: Patching compound to be supplied or approved/recommended by sport surface manufacturer.

F. Line marking: Line marking paint to be supplied by sport surface manufacturer.

1.3 EXECUTION

A. Installation
1. Install sport flooring in accordance with manufacturer's printed instructions.
2. Prefabricated sport flooring shall be unrolled and allowed to relax.
3. Cut and adjust prefabricated sport flooring prior to adhesion.
4. Mix adhesive in accordance with manufacturer's instructions.
5. Hold all seams in place with suitable weights for a minimum of 12 hours.
6. Lines to be painted as per manufacturer's recommendations.
7. Surface to be protected before, during and after installation until project's acceptance by the the Owner or his agent.

END OF SECTION 32 18 16 13b

Task	Specification	Specification Description
32 18 16 13	11 66 13 00	Playground Equipment And Structures
32 18 16 13	11 68 13 00	Recreational Facilities

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SECTION 32 18 23 29 - COLORED ATHLETIC WEARING SURFACE

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of colored athletic wearing surface on asphaltic concrete base. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals: Submit product data and manufacturer's application instruction.

1.2 PRODUCTS

A. Manufacturer: Athletic wearing surface shall be the "Plexipave" system by California Products Corporation, 169 Waverly Street, Cambridge Ma. 02139 or approved equal.

B. Plexipave Court Patch Binder prepared as per manufacturers recommendations.

C. California Acrylic Resurfacer prepared as per manufacturers recommendations.

D. Fortified Plexipave Job Mix prepared as per manufacturers recommendations.

E. Plexipave Color Base as required to meet project requirements.

F. Plexichrome Color as required to meet project requirements.

1.3 EXECUTION:

A. Personnel used to install athletic wearing surface must have a minimum of three years experience and at least three jobs with similar square footage of placement.

B. When required, asphaltic concrete base shall be placed to conform to manufacturer’s planarity requirements.

C. Protect adjacent surfaces not to receive coating during application.

D. All finished surfaces must have a uniform appearance and be free of ridges and tool marks and shall not vary more than 1/8" in 10 feet measured in any direction.

END OF SECTION 32 18 23 29

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SECTION 32 18 23 29a - SYNTHETIC TURF

1.1 GENERAL

A. Description Of Work
1. This section covers the furnishing and/or installation of: synthetic turf with covers for cut-outs; paint lines and markings for football, soccer and baseball fields; the painting of a logo at midfield; line painter equipment, portable blower for ground clean-up, turf vacuum cleaner, and pylon markers. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals:
1. Turf covers for baseball infield cutouts.
2. Painting template for a logo.
3. Layouts for lines and markings of game fields.
4. Maintenance Manual: 2 copies, providing a full description of materials to be used for maintaining Synthetic Turf System.
5. Manufacturer's literature for line painter equipment, turf vacuum cleaner, and portable blowers.
6. Warranties: For synthetic turf, for line painter equipment, for turf vacuum cleaner, and for portable blowers.
7. Synthetic turf: Sample, technical data and manufacturer's directions for installation and maintenance.
8. Line Paint: Manufacturer's literature and application directions.

C. Warranties: The warranty submitted shall have the following characteristics:
1. Shall provide full coverage for eight (8) years, from date of first use.
2. Shall warrant materials and workmanship.
3. Shall warrant that the materials installed meet or exceed the product specifications.
4. Shall have a provision to either: (a) make repairs or (b) replace such portions of the installed materials that are no longer serviceable, to maintain a serviceable and playable surface, and make good without cost or expense to the Owner.
5. Shall state all limitations and exclusions.
6. Shall be a warranty from a single source covering workmanship and all self-manufactured or procured materials.
7. Warranty shall be for full value, not prorated.

1.2 PRODUCTS

A. Synthetic Turf
1. Synthetic turf shall be Astro Turf-8, by Astro Turf Industries, Inc., 809 Kenner Street, Dalton, Georgia 30720, or approved equivalent.
2. Turf fabric: Knitted of nylon 6.6 ribbon with a polyester filament backing yarns and weighing approximately 63 ounces per square yard.
3. Pile material: 500 denier, textured nylon, 6.6 ribbon with a 1/2-inch pile height to give the appearance of mown grass; weight 50 ounces per square yard; pigmented green and stabilized for outdoor exposure.
4. Backing Yarns: High strength polyester fiber yarns, heat set for maximum dimensional stability.

B. Underpad
1. Underpad: 5/8-inch thick, energy-absorbing, made of closed cell foam, reinforced with carbon black, and perforated for drainage.
2. Pad density: 7.5 pounds per cubic foot.
3. Compression module: 25%, 8 pounds per square inch.

4. Perforations: 3/8-inch holes, 3 on center in a staggered pattern, factory perforated.

C. Adhesives for bonding the synthetic turf to the pad shall be weather-resistant to withstand the climate of the site and shall be compatible with the materials of the turf and pad.

D. All butt seams of the turf surface shall be sewn and glued.

E. Paint shall be Sherwin-Williams "Watch-Guard System Metalex" semi-gloss enamel, or approved equivalent.

F. Line painter shall be Model 98-331, as manufactured by Binks Co., or approved equivalent, with 5 gallon pressure-tested tank, adjustable line marker, quick disconnect for ease of cleaning, 12" front pneumatic wheels, 5HP 4-cycle air-cooled gasoline engine, air-actuated spray gun, dual cylinder compressor.

G. Turf vacuum cleaner shall be Model BT-80-VIC, manufactured by the Billy Goat Industries, Inc., Lees Summit, MO, or approved equivalent. Vacuum shall be 8 HP Push-gasoline Big Wheel model complete with 5" intake hose kit (Part No. 800521) exhaust hose kit (Part No. 800077), and caster assembly (Part No. 800065).

H. Portable Blower for Ground Cleanup
1. Windmill "Fast-Blo", Model No. 22B hand-held gas power blower as supplied by A.M. Leonard Inc., Piqua, Ohio, or approved equivalent.
2. Variable speed control, 2-cycle gas engine type, weighing 10 pounds.

I. Football Pylons: Model No. "WP-12"
1. "Ethafoam", water and mildew resistant, size 4" x 4" x18", of standard bright color.
2. Weighted: Springs back upon impact.
3. Provide two (2) sets of twelve (12) pylons for a total of 24, for football field.

J. Soccer Flags
1. Soccer Flags: Model "WSF" as manufactured by Marty Gilman, Inc., Gilman, CT. 06336, or approved equivalent.
2. Provide two (2) sets of four (4) flags for a total of eight, for soccer field.

K. Baseball Infield Conversion System
1. Submit Shop Drawings indicating method of detailing conversion panels for approval.
2. Panels shall be removable in conversion area.
3. Cut panels from same synthetic turf material as football field, to match.
4. Provide spacers and pad wedges.

1.3 EXECUTION

A. Before any synthetic turf is installed, the Contractor shall inspect the asphaltic concrete base and, when satisfied with its condition, shall notify the Owner in writing of acceptance of the base.

B. A manufacturer's representative shall be present at the job site when the synthetic turf is installed. Turf shall be laid in strict accordance with the manufacturer's instructions by workmen who are skilled in this type of work.

C. Turf material shall be protected before, during and after installation.

D. Installed work and materials of other trades shall be protected.

E. Assurance
1. Qualified bidders must have successfully installed at least five (5) other outdoor installations of synthetic stadium surface within the last three (3) years of a type described herein.
2. The field installation shall be made under the direct, active, personal supervision of technical representatives of the synthetic turf manufacturer. All key positions shall be manned by experienced employees of the installer.
3. The synthetic turf contractor shall keep a full-time superintendent on the project during the installation of the synthetic turf.
4. The synthetic turf system supplied shall be of previous acceptance at all levels of competition, including University and Professional.

F. Underpad Installation
1. At "float drain" system: strip glue underpad at all joints.
2. At "vertical drain" system: provide intermittent gluing at a spread rate of 150-160 sq. ft./gal.
3. Sew Pad joints, using thread and stitching recommended by the synthetic turf manufacturer.
4. Lay out work so that seams of the underpad are offset from the seams of turf, but not less than 12".

G. Turf Installation
1. The synthetic turf shall be bonded to the pad with no wrinkles, ripples or bubbles. Slits in the fabric to relieve such defects are not permitted. Joints in the turf shall be offset from joints of the pad by not less than 12".
2. Side seams in the fabric shall be at 15'-0" intervals, at 5-yard lines for the football field. There shall be no cross or head seams.
3. Sew seams with high strength polyester fiber cord and lay with a bed of adhesive. Seams shall be flat, tight and permanent, with no separation or fraying.
4. Covers for the baseball infield cut-outs shall be flush and tight. Install covers and check for proper fittings.
5. Insert edges of turf in trench drain receptor at perimeter of field for "float drain" systems; terminated edges at concrete curb and wood nailer at "vertical drain" systems.
6. Provide covering caps for football and soccer goal posts and markers within the playing fields.
7. At completion, remove all excess materials and all debris resulting from operations of Work in this Section. Leave entire Work in neat, clean condition.

H. Painting
1. Lines and markings for game fields shall be painted in accordance with the approved Shop Drawings.
2. Any logo shall be painted at midfield in accordance with the approved Shop Drawings.

I. Maintenance
1. Manual shall describe the materials, devices and procedures to be followed for use and maintenance or the synthetic turf system, including the cleaning, paint application and removal, and conversion techniques. Include any precautions required by the warranty.
2. Training: Give demonstrations and training sessions, devoting a sufficient amount of time to thoroughly instruct the Owner's personnel in operation and maintenance (for cleaning, conversion of baseball-to-football, and line striping) of the synthetic turf system and equipment.

J. Acceptance
1. Before the acceptance of the work, should any imperfect areas or spots develop in the surface, such areas shall be removed and replaced with new materials.
2. All such repair work shall be done at no additional cost to the Owner.

K. At the completion of the Work, remove all material scraps, debris, and equipment from the site and leave the synthetic turf area ready for use.

END OF SECTION 32 18 23 29a

Task	Specification	Specification Description
32 18 23 29	32 18 16 13a	Track, Court, And Playground Markings
32 18 23 29	11 68 23 13	Playing Fields
32 18 23 33	32 18 23 29	Colored Athletic Wearing Surface
32 18 23 33	32 18 23 29a	Synthetic Turf
32 18 23 33	32 18 16 13a	Track, Court, And Playground Markings
32 18 23 33	32 18 16 13b	Synthetic Running Track Surface
32 18 23 39	32 18 23 29	Colored Athletic Wearing Surface
32 18 23 39	32 18 23 29a	Synthetic Turf
32 18 23 39	32 18 16 13a	Track, Court, And Playground Markings
32 18 23 39	32 18 16 13b	Synthetic Running Track Surface
32 18 23 53	32 18 16 13a	Track, Court, And Playground Markings
32 18 23 53	11 68 23 13	Playing Fields
32 18 23 56	32 18 23 29	Colored Athletic Wearing Surface
32 18 23 56	32 18 23 29a	Synthetic Turf
32 18 23 56	32 18 16 13a	Track, Court, And Playground Markings
32 18 23 56	11 68 23 13	Playing Fields
32 18 23 61	32 18 23 29	Colored Athletic Wearing Surface
32 18 23 61	32 18 23 29a	Synthetic Turf
32 18 23 61	32 18 16 13a	Track, Court, And Playground Markings

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SECTION 32 31 11 00 - CHAIN-LINK FENCES AND GATES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for chain-link fences and gates. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
   a. Chain-link fences.
   b. Gates: Manually and Motor operated, horizontal slide and swing.

C. Performance Requirements
1. Delegated Design: Design chain-link fences and gates, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance: Chain-link fence and gate framework shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to ASCE/SEI 7:
   a. Minimum Post Size and Maximum Spacing: Determine according to CLFMI WLG 2445, based on mesh size and pattern specified and on the following:
      1) Wind Loads: **<Insert loads required for Project location>**.
      2) Exposure Category: B **OR** C **OR** D, **as directed**.
      3) Fence Height: 10 feet (3 m).
      4) Material Group: IA, ASTM F 1043, Schedule 40 steel pipe **OR** IC, electric-resistance-welded round steel pipe, **as directed**.
3. Lightning Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

D. Submittals
1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for chain-link fences and gates.
   a. Fence and gate posts, rails, and fittings.
   b. Chain-link fabric, reinforcements, and attachments.
   c. Accessories: Privacy slats **OR** Barbed wire **OR** Barbed tape, **as directed**.
   d. Gates and hardware.
   e. Gate operators, including operating instructions.
   f. Motors: Show nameplate data, ratings, characteristics, and mounting arrangements.
2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work. Show accessories, hardware, gate operation, and operational clearances.
   a. Gate Operator: Show locations and details for installing operator components, switches, and controls. Indicate motor size, electrical characteristics, drive arrangement, mounting, and grounding provisions.
   b. Wiring Diagrams: For power, signal, and control wiring.
3. Samples: Prepared on Samples of size indicated below:
   a. Polymer-Coated Components: In 6-inch (150-mm) lengths for components and on full-sized units for accessories.
4. Delegated-Design Submittal: For chain-link fences and gate framework indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

5. Qualification Data: For qualified professional engineer **OR** testing agency **OR** factory-authorized service representative, **as directed**.
6. Product Certificates: For each type of chain-link fence, operator, and gate, from manufacturer.
7. Product Test Reports: For framing strength according to ASTM F 1043.
8. Field quality-control reports.
9. Operation and Maintenance Data: For the following to include in emergency, operation, and maintenance manuals:
   a. Polymer finishes.
   b. Gate hardware.
   c. Gate operator.
10. Warranty: Sample of special warranty.

E. Quality Assurance
1. Testing Agency Qualifications: For testing fence grounding. Member company of NETA or an NRTL.
   a. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Emergency Access Requirements: Comply with requirements of authorities having jurisdiction for gates with automatic gate operators serving as a required means of access.
4. Preinstallation Conference: Conduct conference at Project site.

F. Project Conditions
1. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

G. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer **OR** Installer, **as directed**, agrees to repair or replace components of chain-link fences and gates that fail in materials or workmanship within specified warranty period.
   a. Failures include, but are not limited to, the following:
      1) Faulty operation of gate operators and controls.
      2) Deterioration of metals, metal finishes, and other materials beyond normal weathering.
   b. Warranty Period: Five **OR** 15, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Chain-Link Fence Fabric
1. General: Provide fabric in one-piece heights measured between top and bottom of outer edge of selvage knuckle or twist. Comply with CLFMI Product Manual and with requirements indicated below:
   a. Fabric Height: As indicated on Drawings **OR** As directed.
   b. Steel Wire Fabric: Wire with a diameter of 0.192 inch (4.88 mm) **OR** 0.148 inch (3.76 mm) **OR** 0.120 inch (3.05 mm) **OR** 0.113 inch (2.87 mm), **as directed**.
      1) Mesh Size: 2-1/8 inches (54 mm) **OR** 2 inches (50 mm) **OR** 1-3/4 inches (44 mm) **OR** 1 inch (25 mm), **as directed**.
      2) Aluminum-Coated Fabric: ASTM A 491, Type I, 0.40 oz./sq. ft. (122 g/sq. m) **OR** 0.35 oz./sq. ft. (107 g/sq. m) **OR** 0.30 oz./sq. ft. (92 g/sq. m), **as directed**.
      3) Zinc-Coated Fabric: ASTM A 392, Type II, Class 1, 1.2 oz./sq. ft. (366 g/sq. m) **OR** Class 2, 2.0 oz./sq. ft. (610 g/sq. m), **as directed**, with zinc coating applied before **OR** after, **as directed**, weaving.

4) Zn-5-Al-MM Aluminum-Mischmetal-Coated Fabric: ASTM F 1345, Type III, Class 1, 0.60 oz./sq. ft. (183 g/sq. m) **OR** Class 2, 1.0 oz./sq. ft. (305 g/sq. m), **as directed**.
5) Polymer-Coated Fabric: ASTM F 668, Class 1 **OR** Class 2a **OR** Class 2b, **as directed**, over aluminum **OR** zinc **OR** Zn-5-Al-MM-alloy, **as directed**,-coated steel wire.
a) Color: Dark green **OR** Olive green **OR** Brown **OR** Black **OR** As selected from manufacturer's full range, **as directed**, complying with ASTM F 934.
6) Coat selvage ends of fabric that is metallic coated before the weaving process with manufacturer's standard clear protective coating.

c. Aluminum Wire Fabric: ASTM F 1183, with mill **OR** caustic-cleaned or etched, **as directed**, finish, and wire diameter of 0.148 inch (3.76 mm) **OR** 0.192 inch (4.88 mm), **as directed**.
1) Mesh Size: 2 inches (50 mm) **OR** 1 inch (25 mm), **as directed**.

d. Selvage: Knuckled at both selvages **OR** Twisted top and knuckled bottom, **as directed**.

B. Fence Framing

1. Posts and Rails: Comply with ASTM F 1043 for framing, including rails, braces, and line; terminal; and corner posts. Provide members with minimum dimensions and wall thickness according to ASTM F 1043 or ASTM F 1083, **as directed**, based on the following:

a. Fence Height: 72 inches (1830 mm) **OR** 96 inches (2440 mm) **OR** As indicated on Drawings, **as directed**.

b. Light Industrial Strength: Material Group IC-L, round steel pipe, electric-resistance-welded pipe **OR** Group II-L, roll-formed steel C-section shapes **OR** Group III-L, hot-rolled H-beam shapes **OR** Group IV, Alternative Design, **as directed**.
1) Line Post: 1.9 inches (48 mm) in diameter **OR** 2.375 inches (60 mm) in diameter **OR** 2.875 inches (73 mm) in diameter **OR** 2.25 by 1.7 inches (57 by 43 mm), **as directed**.
2) End, Corner and Pull Post: 2.375 inches (60 mm) **OR** 2.875 inches (73 mm) **OR** 4.0 inches (102 mm) **OR** 2.25 by 1.7 inches (57 by 43 mm), **as directed**.

c. Heavy Industrial Strength: Material Group IA, round steel pipe, Schedule 40 **OR** Group IC, round steel pipe, electric-resistance-welded pipe **OR** Group II, roll-formed steel C-section shapes **OR** Group III, hot-rolled H-beam shapes **OR** Group IV, Alternative Design, **as directed**.
1) Line Post: 1.9 inches (48 mm) in diameter **OR** 2.375 inches (60 mm) in diameter **OR** 2.875 inches (73 mm) in diameter **OR** 4.0 inches (102 mm) in diameter **OR** 6.625 inches (168 mm) in diameter **OR** 1.875 by 1.63 inches (48 by 41 mm) **OR** 2.25 by 1.70 inches (67 by 43 mm) **OR** 3.25 by 2.50 inches (83 by 64 mm), **as directed**.
2) End, Corner and Pull Post: 2.375 inches (60 mm) in diameter **OR** 2.875 inches (73 mm) in diameter **OR** 4.0 inches (102 mm) in diameter **OR** 6.625 inches (168 mm) in diameter **OR** 2.25 by 1.70 inches (67 by 43 mm) **OR** 3.25 by 2.50 inches (83 by 64 mm) **OR** 3.5 by 1.5 inches (89 by 38 mm), **as directed**.

d. Horizontal Framework Members: Intermediate, top and bottom rails, **as directed**, complying with ASTM F 1043.
1) Top Rail: 1.66 inches (42 mm) in diameter **OR** 1.25 by 1.63 inches (32 by 41 mm), **as directed**.

e. Brace Rails: Comply with ASTM F 1043.

f. Metallic Coating for Steel Framing:
1) Type A, consisting of not less than minimum 2.0-oz./sq. ft. (0.61-kg/sq. m) average zinc coating per ASTM A 123/A 123M or 4.0-oz./sq. ft. (1.22-kg/sq. m) zinc coating per ASTM A 653/A 653M.
2) Type B, zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. (0.27 kg/sq. m) of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film.
3) External, Type B, zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. (0.27 kg/sq. m) of zinc after welding, a chromate conversion coating, and a clear,

verifiable polymer film. Internal, Type D, consisting of 81 percent, not less than 0.3-mil- (0.0076-mm-) thick, zinc-pigmented coating.

4) Type C, Zn-5-Al-MM alloy, consisting of not less than 1.8-oz./sq. ft. (0.55-kg/sq. m) coating.

5) Coatings: Any coating above.

g. Polymer coating over metallic coating.

1) Color: Match chain-link fabric **OR** Dark green **OR** Olive green **OR** Brown **OR** Black **OR** As selected from manufacturer's full range, **as directed**, complying with ASTM F 934.

C. Tension Wire

1. Metallic-Coated Steel Wire: 0.177-inch- (4.5-mm-) diameter, marcelled tension wire complying with ASTM A 817 and ASTM A 824, with the following metallic coating:
   a. Type I, aluminum coated (aluminized).
   b. Type II, zinc coated (galvanized) by hot-dip **OR** electrolytic, **as directed**, process, with the following minimum coating weight:
      1) Class 3: Not less than 0.8 oz./sq. ft. (244 g/sq. m) of uncoated wire surface.
      2) Class 4: Not less than 1.2 oz./sq. ft. (366 g/sq. m) of uncoated wire surface.
      3) Class 5: Not less than 2 oz./sq. ft. (610 g/sq. m) of uncoated wire surface.
      4) Matching chain-link fabric coating weight.
   c. Type III, Zn-5-Al-MM alloy with the following minimum coating weight:
      1) Class 60: Not less than 0.6 oz./sq. ft. (183 g/sq. m) of uncoated wire surface.
      2) Class 100: Not less than 1 oz./sq. ft. (305 g/sq. m) of uncoated wire surface.
      3) Matching chain-link fabric coating weight.
2. Polymer-Coated Steel Wire: 0.177-inch- (4.5-mm-) **OR** 0.148-inch- (3.8-mm-), **as directed**, diameter, tension wire complying with ASTM F 1664, Class 1 **OR** Class 2a **OR** Class 2b, **as directed**, over aluminum **OR** zinc **OR** Zn-5-Al-MM-alloy, **as directed**,-coated steel wire.
   a. Color: Match chain-link fabric **OR** Dark green **OR** Olive green **OR** Brown **OR** Black **OR** As selected from manufacturer's full range, **as directed**, complying with ASTM F 934.
3. Aluminum Wire: 0.192-inch- (4.88-mm-) diameter tension wire, mill finished, complying with ASTM B 211 (ASTM B211M), Alloy 6061-T94 with 50,000-psi (344-MPa) minimum tensile strength.

D. Swing Gates

1. General: Comply with ASTM F 900 for gate posts and single **OR** double, **as directed**, swing gate types. Provide automated vehicular gates that comply with ASTM F 2200, **as directed**.
   a. Gate Leaf Width: 36 inches (914 mm) **OR** As indicated, **as directed**.
   b. Gate Fabric Height: 72 inches (1830 mm) or less **OR** More than 72 inches (1830 mm) **OR** As indicated, **as directed**.
2. Pipe and Tubing:
   a. Zinc-Coated Steel: Comply with ASTM F 1043 and ASTM F 1083; protective coating and finish to match fence framing **OR** manufacturer's standard protective coating and finish, **as directed**.
   b. Aluminum: Comply with ASTM B 429/B 429M; mill **OR** manufacturer's standard, **as directed**, finish.
   c. Gate Posts: Round tubular steel **OR** Rectangular tubular steel **OR** Round tubular aluminum **OR** Rectangular tubular aluminum, **as directed**.
   d. Gate Frames and Bracing: Round tubular steel **OR** Rectangular tubular steel **OR** Round tubular aluminum **OR** Rectangular tubular aluminum, **as directed**.
3. Frame Corner Construction: Welded **OR** Assembled with corner fittings, **as directed**.
4. Extended Gate Posts and Frame Members: Extend gate posts and frame end members above top of chain-link fabric at both ends of gate frame 12 inches (300 mm) **OR** as indicated, **as directed**, to attach barbed wire **OR** tape, **as directed**, assemblies.
5. Hardware:

a. Hinges: 180-degree inward **OR** 180-degree outward **OR** 360-degree inward and outward, **as directed**, swing.
b. Latches permitting operation from both sides of gate with provision for padlocking accessible from both sides of gate, **as directed**.
c. Padlock and Chain: Owner furnished.
d. Lock: Manufacturer's standard internal device furnished in lieu of gate latch, **as directed**.
e. Closer: Manufacturer's standard, **as directed**.

E. Horizontal-Slide Gates
1. General: Comply with ASTM F 1184 for gate posts and single **OR** double, **as directed**, sliding gate types. Provide automated vehicular gates that comply with ASTM F 2200, **as directed**.
a. Classification: Type I Overhead Slide (opening widths to 40 feet (12.2 m) with an overhead clearance of up to 22 feet (6.7 m)).
1) Gate Leaf Width: As indicated **OR** As directed.
2) Gate Fabric Height: 72 inches (1830 mm) or less **OR** More than 72 inches (1830 mm) **OR** As indicated, **as directed**.
b. Classification: Type II Cantilever Slide (opening widths to 30 feet (9.1 m) and heights to 8 feet (2.44 m))
1) Class 1 with external **OR** Class 2 with internal, **as directed**, roller assemblies.
2) Gate Frame Width and Height: 48 inches (1200 mm) wide or less by 72 inches (1830 mm) high or less **OR** More than 48 inches (1200 mm) wide by any height **OR** As indicated, **as directed**.
2. Pipe and Tubing:
a. Zinc-Coated Steel: Protective coating and finish to match fence framing **OR** Manufacturer's standard protective coating and finish, **as directed**.
b. Aluminum: Comply with ASTM B 429/B 429M; mill **OR** manufacturer's standard, **as directed**, finish.
c. Gate Posts: Comply with ASTM F 1184. Provide round tubular steel **OR** rectangular tubular steel **OR** round tubular aluminum **OR** rectangular tubular aluminum, **as directed**, posts.
d. Gate Frames and Bracing: Round tubular steel **OR** Rectangular tubular steel **OR** Round tubular aluminum **OR** Rectangular tubular aluminum, **a directed**.
3. Frame Corner Construction: Welded **OR** Assembled with corner fittings, **as directed**.
4. Extended Gate Posts and Frame Members: Extend gate posts and frame end members above top of chain-link fabric at both ends of gate frame 12 inches (300 mm) **OR** as indicated, **as directed,** as required to attach barbed wire **OR** tape, **as directed**, assemblies.
5. Overhead Track Assembly: Manufacturer's standard track, with overhead framing supports, bracing, and accessories, engineered to support size, weight, width, operation, and design of gate and roller assemblies.
6. Hardware:
a. Latches permitting operation from both sides of gate with provision for padlocking accessible from both sides of gate, **as directed**.
b. Padlock and Chain: Owner furnished.
c. Lock: Manufacturer's standard internal device furnished in lieu of gate latch, **as directed**.
d. Hangers, roller assemblies, and stops fabricated from galvanized steel **OR** galvanized malleable iron **OR** mill-finished Grade 319 aluminum-alloy casting with stainless-steel fasteners, **as directed**.

F. Fittings
1. General: Comply with ASTM F 626.
2. Post Caps: Provide for each post.
a. Provide line post caps with loop to receive tension wire or top rail.
3. Rail and Brace Ends: For each gate, corner, pull, and end post.
4. Rail Fittings: Provide the following:
a. Top Rail Sleeves: Pressed-steel or round-steel tubing **OR** Aluminum Alloy 6063, **as directed**, not less than 6 inches (152 mm) long.

b. Rail Clamps: Line and corner boulevard clamps for connecting intermediate, and bottom, **as directed**, rails in the fence line-to-line posts.

5. Tension and Brace Bands: Pressed steel **OR** Aluminum Alloy 6063, **as directed**.
6. Tension Bars: Steel **OR** Aluminum **OR** Fiberglass, **as directed**, length not less than 2 inches (50 mm) shorter than full height of chain-link fabric. Provide one bar for each gate and end post, and two for each corner and pull post, unless fabric is integrally woven into post.
7. Truss Rod Assemblies: Steel, hot-dip galvanized after threading **OR** Mill-finished aluminum, **as directed**, rod and turnbuckle or other means of adjustment.
8. Barbed Wire Arms: Pressed steel or cast iron **OR** Aluminum, **as directed**, with clips, slots, or other means for attaching strands of barbed wire, and means for attaching to posts **OR** integral with post cap, **as directed**; for each post unless otherwise indicated, and as follows:
   a. Provide line posts with arms that accommodate top rail or tension wire.
   b. Provide corner arms at fence corner posts, unless extended posts are indicated.
   c. Type I, single slanted arm.
   d. Type II, single vertical arm.
   e. Type III, V-shaped arm.
   f. Type IV, A-shaped arm.
9. Tie Wires, Clips, and Fasteners: According to ASTM F 626.
   a. Standard Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, complying with the following:
      1) Hot-Dip Galvanized Steel: 0.106-inch- (2.69-mm-) **OR** 0.148-inch- (3.76-mm-), **as directed**, diameter wire; galvanized coating thickness matching coating thickness of chain-link fence fabric, **as directed**.
      2) Aluminum: ASTM B 211 (ASTM B 211M); Alloy 1350-H19; 0.148-inch- (3.76-mm-) **OR** 0.192-inch- (4.88-mm-), **as directed**, diameter, mill-finished wire.
10. Finish:
    a. Metallic Coating for Pressed Steel or Cast Iron: Not less than 1.2 oz. /sq. ft. (366 g /sq. m) zinc.
       1) Polymer coating over metallic coating.
    b. Aluminum: Mill finish.

G. Privacy Slats

1. Material: PVC, UV-light stabilized, flame resistant, four ply, **as directed**, not less than 0.006 inch (0.15 mm) **OR** 0.023 inch (0.58 mm), **as directed**, thick; attached to not less than 0.0475-inch- (1.21-mm-) diameter, twisted galvanized wire; hedge-type lattice, **as directed**; sized to fit mesh specified for direction indicated.
   OR
   Material: Polyethylene tubular slats, not less than 0.023 inch (0.58 mm) thick, manufactured for chain-link fences from virgin polyethylene containing UV inhibitor, sized to fit mesh specified for direction indicated; with vandal-resistant fasteners and lock strips **OR** fins for increased privacy factor, **as directed**.
   OR
   Material: Fiber-glass-reinforced plastic, UV-light stabilized, not less than 0.06 inch (1.5 mm) thick, sized to fit mesh specified for direction indicated; with vandal-resistant fasteners and lock strips, **as directed**.
   OR
   Material: Aluminum, not less than 0.01 inch (0.25 mm) thick, sized to fit mesh specified for direction indicated.
   OR
   Material: Redwood, 5/16 inch (7.9 mm) thick, sized to fit mesh specified for direction indicated.
2. Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range **OR** As indicated on Drawings, **as directed**.

H. Barbed Wire

1. Steel Barbed Wire: Comply with ASTM A 121, for two-strand barbed wire, 0.099-inch- (2.51-mm-) diameter line wire with 0.080-inch- (2.03-mm-) diameter, four-point round barbs spaced not more than 5 inches (127 mm) o.c.
   a. Aluminum Coating: Type A.
   b. Zinc Coating: Type Z, Class 3.
2. Polymer-Coated, Galvanized-Steel Barbed Wire: Comply with ASTM F 1665 two-strand barbed wire, 0.080-inch- (2.03-mm-) diameter line wire with 0.080-inch- (2.03-mm-) diameter, four-point round aluminum alloy **OR** galvanized-steel, **as directed**, barbs spaced not more than 5 inches (127 mm) o.c.:
   a. Polymer Coating: Class 1 **OR** Class 2a **OR** Class 2b, **as directed**, over aluminum **OR** zinc **OR** Zn-5-Al-MM-alloy, **as directed**,-coated steel wire.
      1) Color: Match chain-link fabric **OR** Dark green **OR** Olive green **OR** Brown **OR** Black **OR** As selected from manufacturer's full range, **as directed**, complying with ASTM F 934.

I. Barbed Tape
1. Wire-Reinforced Tape: ASTM F 1910; with four-point, needle-sharp barbs permanently cold clenched around a core wire.
   a. Core Wire: High-tensile-strength, zinc-coated steel **OR** stainless steel, **as directed**.
2. Clips: Stainless steel, 0.065 inch (1.7 mm) thick by 0.375 inch (9.5 mm) wide, capable of withstanding a minimum 150-lbf (667-N) pull load to limit extension of coil, resulting in a concertina pattern when deployed.
3. Tie Wires: Stainless steel, 0.065 inch (1.7 mm) in diameter.
4. Fabrication: Continuous coils of barbed tape as defined in ASTM F 1379 for the following characteristics:
   a. Configuration: Single **OR** Double, **as directed**, coil.
   b. Style: Helical **OR** Concertina, **as directed**, pattern.
   c. Coil Diameter(s): 18 inches (457 mm) **OR** 24 inches (610 mm) **OR** 24-inch (610-mm) inner coil and 30-inch (762-mm) outer coil **OR** As indicated on Drawings, **as directed**.
   d. Coil Loop Spacing(s): 12 inches (300 mm) **OR** Manufacturer's standard **OR** As indicated on Drawings, **as directed**.
   e. Barb Length Classification: Long, 1.2-inch (30.5-mm) **OR** Medium, 0.4-inch (10.2-mm) **OR** Short, 0.1875-inch (4.76-mm), **as directed**, barb.
   f. Barb Spacing: 4 inches (102 mm) o.c.
   g. Barb Set: Straight **OR** Offset **OR** Manufacturer's standard, **as directed**.

J. Gate Operators
1. General: Provide factory-assembled automatic operating system designed for gate size, type, weight, and operation frequency. Provide operation control system with characteristics suitable for Project conditions, with remote-control stations, safety devices, and weatherproof enclosures; coordinate electrical requirements with building electrical system.
   a. Provide operator designed so motor may be removed without disturbing limit-switch adjustment and without affecting auxiliary emergency operator.
   b. Provide operator with UL approval **OR** -approved components, **as directed**.
   c. Provide electronic components with built-in troubleshooting diagnostic feature.
   d. Provide unit designed and wired for both right-hand/left-hand opening, permitting universal installation.
2. Comply with NFPA 70.
3. UL Standard: Fabricate and label gate operators to comply with UL 325.
4. Motor Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, within installed environment, with indicated operating sequence, and without exceeding nameplate rating or considering service factor. Comply with NEMA MG 1 and the following:
   a. Voltage: 12-V dc **OR** 120 V **OR** 208-220 V **OR** NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected, **as directed**.
   b. Horsepower: 1/4 **OR** 1/3 **OR** 3/4, **as directed**.
   c. Enclosure: Open dripproof **OR** Totally enclosed **OR** Manufacturer's standard, **as directed**.

d. Duty: Continuous duty at ambient temperature of 105 deg F (40 deg C) and at altitude of 3300 feet (1005 m) above sea level.
e. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.
f. Phase: One **OR** Polyphase, **as directed**.

5. Gate Operators: Gate **OR** Equipment base/pad **OR** Pedestal post **OR** In ground, **as directed**, mounted and as follows:
   a. Hydraulic Swing **OR** Slide, **as directed**, Gate Operators:
      1) Duty: Light **OR** Medium **OR** Heavy, **as directed**, duty, residential **OR** commercial/industrial, **as directed**.
      2) Gate Speed: Minimum 45 feet (13.7 m) **OR** 60 feet (18.2 m), **as directed**, per minute.
      3) Maximum Gate Weight: 300 lb (137 kg).
      4) Frequency of Use: 10 cycles per hour **OR** 25 cycles per hour **OR** Continuous duty, **as directed**.
      5) Locking: Hydraulic in both directions.
      6) Heater: Manufacturer's standard track and roller heater with thermostatic control.
      7) Operating Type: Crank arm **OR** Wheel and rail drive **OR** Roller chain, **as directed**, with manual release, **as directed**.
   b. Mechanical Swing **OR** Slide, **as directed**, Gate Operators:
      1) Duty: Light **OR** Medium **OR** Heavy, **as directed**, duty, residential **OR** commercial/industrial, **as directed**.
      2) Gate Speed: Minimum 45 feet (13.7 m) per minute **OR** 60 feet (18.2 m) per minute **OR** variable speed, **as directed**.
      3) Maximum Gate Weight: 600 lb (272 kg) **OR** 800 lb (363 kg), **as directed**.
      4) Frequency of Use: 10 cycles per hour **OR** 25 cycles per hour **OR** 60 cycles per hour **OR** Continuous duty, **as directed**.
      5) Operating Type: Crank arm **OR** Wheel and rail drive **OR** Roller chain, **as directed**, with manual release, **as directed**.
      6) Drive Type: Enclosed worm gear **OR** worm gear and chain-and-sprocket, **as directed**, reducers, roller-chain drive.
         OR
         Drive Type: V-belt and worm gear **OR** chain-and-sprocket, **as directed**, reducers, roller-chain drive.

6. Remote Controls: Electric controls separated from gate and motor and drive mechanism, with NEMA ICS 6, Type 1 **OR** NEMA ICS 6, Type 4, **as directed**, enclosure for surface **OR** recessed or flush **OR** equipment base/pad **OR** pedestal, **as directed**, mounting and with space for additional optional equipment. Provide the following remote-control device(s):
   a. Control Station: Keyed, two **OR** three, **as directed**,-position switch, located remotely from gate. Provide two keys per station.
      OR
      Control Station: Momentary-contact, single **OR** three, **as directed**,-button-operated; located remotely from gate. Key switch to lock out open and close buttons, **as directed**.
      1) Function: Open, stop, **as directed**, and close.
   b. Card Reader: Functions only when authorized card is presented. Programmable, magnetic multiple **OR** single, **as directed**,-code system, permitting four different access time periods, **as directed**; face-lighted unit fully visible at night, **as directed**.
      1) Reader Type: Touch plate **OR** Swipe **OR** Insertion **OR** Proximity, **as directed**.
      2) Features: Timed anti-passback **OR** Limited-time usage **OR** Capable of monitoring and auditing gate activity, **as directed**.
   c. Digital Keypad Entry Unit: Multiple-code capability **OR** Multiple-programmable, code capability, **as directed**, of not less than five **OR** 500 **OR** 2500, **as directed**, possible individual codes, consisting of one- to seven **OR** four **OR** five, **as directed**,-digit codes, and permitting four different access time periods, **as directed**.
      1) Features: Timed anti-passback **OR** Limited-time usage **OR** Capable of monitoring and auditing gate activity, **as directed**.

2) Face-lighted unit with metal-keyed **OR** keyless-membrane, **as directed**, keypad fully visible at night.

d. Radio Control: Digital system consisting of code-compatible universal receiver for each gate, located where indicated, with remote antenna with coaxial cable and mounting brackets designed to operate gates. Provide one **OR** two, **as directed**, programmable transmitter(s) with multiple-code capability permitting validating or voiding of not less than 1000 **OR** 10,000, **as directed**, codes per channel configured for the following functions:
   1) Transmitters: Single **OR** Three, **as directed**,-button operated, with open **OR** open and close, **as directed**, function.
   2) Channel Settings: Two **OR** Three **OR** Four, **as directed**, independent channel settings controlling separate receivers for operating more than one gate from each transmitter.

e. Telephone Entry System: Hands-free voice-communication system for connection to building telephone system with digital-entry code activation of gate operator and auxiliary keypad entry, **as directed**.
   1) Residential System: Designed to be wired to same line with telephone.
      OR
      Multiunit System: Designed to be wired to a dedicated telephone line, with capacity to access 20 **OR** 100, **as directed**, telephones and with electronic directory, **as directed**.

f. Vehicle Loop Detector: System including automatic closing timer with adjustable time delay before closing, timer cut-off switch, **as directed**, and loop detector designed to open and close gate **OR** hold gate open until traffic clears **OR** reverse gate, **as directed**. Provide electronic detector with adjustable detection patterns, adjustable sensitivity and frequency settings, and panel indicator light designed to detect presence or transit of a vehicle over an embedded loop of wire and to emit a signal activating the gate operator. Provide number of loops consisting of multiple strands of wire, number of turns, loop size, and method of placement at location shown on Drawings, as recommended in writing by detection system manufacturer for function indicated.
   1) Loop: Wire, in size indicated for field assembly, for pave-over **OR** saw-cut with epoxy-grouted, **as directed**, installation.
      OR
      Loop: Factory preformed in size indicated; style for pave-over **OR** saw-cut with epoxy-grouted, **as directed**, installation.

g. Vehicle Presence Detector: System including automatic closing timer with adjustable time delay before closing, timer cut-off switch, **as directed**, and presence detector designed to open and close gate **OR** hold gate open until traffic clears **OR** reverse gate, **as directed**. Provide retroreflective **OR** emitter/receiver, **as directed**, detector with adjustable detection zone pattern and sensitivity, designed to detect the presence or transit of a vehicle in gate pathway when infrared beam in zone pattern is interrupted, and to emit a signal activating the gate operator.

7. Obstruction Detection Devices: Provide each motorized gate with automatic safety sensor(s). Activation of sensor(s) causes operator to immediately function as follows:

a. Action: Reverse gate in both opening and closing cycles and hold until clear of obstruction **OR** Stop gate in opening cycle and reverse gate in closing cycle and hold until clear of obstruction, **as directed**.

b. Internal Sensor: Built-in torque or current monitor senses gate is obstructed.

c. Sensor Edge: Contact-pressure-sensitive safety edge, profile, and sensitivity designed for type of gate and component indicated, in locations as follows. Connect to control circuit using take-up cable reel **OR** self-coiling cable **OR** gate edge transmitter and operator receiver system, **as directed**.
   1) Along entire gate leaf leading edge (for swing gates and slide gates).
   2) Along entire gate leaf trailing edge (for slide gates).
   3) Across entire gate leaf bottom edge (for vehicular swing and slide gates complying with UL 325 or to suit Project; consider retaining for pedestrian gates).

4) Along entire length of gate posts (for slide gates; revise for sensor edge at pinch point post of swing gates).
5) Along entire length of gate guide posts (for Type II Cantilever Slide, Class 1 gates).
6) Where indicated on Drawings.

d. Photoelectric/Infrared Sensor System: Designed to detect an obstruction in gate's path when infrared beam in the zone pattern is interrupted.

8. Limit Switches: Adjustable switches, interlocked with motor controls and set to automatically stop gate at fully retracted and fully extended positions.
   a. Type: Integral fail-safe release, allowing gate to be pushed open without mechanical devices, keys, cranks, or special knowledge **OR** Mechanical device, key, or crank-activated release, **as directed**.
9. Operating Features:
   a. Digital Microprocessor Control: Electronic programmable means for setting, changing, and adjusting control features with capability for monitoring and auditing gate activity, **as directed**. Provide unit that is isolated from voltage spikes and surges.
   b. System Integration: With controlling circuit board capable of accepting any type of input from external devices.
   c. Master/Slave Capability: Control stations designed and wired for gate pair operation.
   d. Automatic Closing Timer: With adjustable time delay before closing and timer cut-off switch, **as directed**.
   e. Open Override Circuit: Designed to override closing commands.
   f. Reversal Time Delay: Designed to protect gate system from shock load on reversal in both directions.
   g. Maximum Run Timer: Designed to prevent damage to gate system by shutting down system if normal time to open gate is exceeded.
   h. Clock Timer: 24-hour **OR** Seven-day, **as directed**, programmable for regular events.
10. Accessories:
    a. Warning Module: Audio **OR** Visual, **as directed**, constant **OR** strobe, **as directed**,-light alarm sounding three to five seconds in advance of gate operation and continuing until gate stops moving; compliant with the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines.
    b. Battery Backup System: Battery-powered drive and access-control system, independent of primary drive system.
       1) Fail Safe: Gate opens and remains open until power is restored.
       2) Fail Secure: Gate cycles on battery power, then fail safe when battery is discharged.
    c. External electric-powered solenoid **OR** magnetic, **as directed**, lock with delay timer allowing time for lock to release before gate operates.
    d. Fire **OR** Postal, **as directed**, box.
    e. Fire strobe **OR** siren, **as directed**, alarm.
    f. Intercom System: <**Insert requirements**>.
    g. Instructional, Safety, and Warning Labels and Signs: According to UL 325 **OR** Manufacturer's standard for components and features specified **OR** As indicated on Drawings, **as directed**.
    h. Equipment Bases/Pads: Cast-in-place or precast concrete, depth not less than 12 inches (300 mm), dimensioned and reinforced according to gate-operator component manufacturer's written instructions and as indicated on Drawings.

K. Grout And Anchoring Cement
1. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout, recommended in writing by manufacturer, for exterior applications.
2. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to

erosion from water exposure without needing protection by a sealer or waterproof coating and that is recommended in writing by manufacturer, for exterior applications.

L. Fence Grounding
1. Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.
a. Material above Finished Grade: Copper **OR** Aluminum, **as directed**.
b. Material on or below Finished Grade: Copper.
c. Bonding Jumpers: Braided copper tape, 1 inch (25 mm) wide, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.
2. Connectors and Grounding Rods: Comply with UL 467.
a. Connectors for Below-Grade Use: Exothermic welded type.
b. Grounding Rods: Copper-clad steel, 5/8 by 96 inches (16 by 2440 mm).

1.3 EXECUTION

A. Examination
1. Examine areas and conditions, with Installer present, for compliance with requirements for a verified survey of property lines and legal boundaries, **as directed**, site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.
a. Do not begin installation before final grading is completed unless otherwise permitted by the Owner.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation
1. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet (152.5 m) or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

C. Installation, General
1. Install chain-link fencing to comply with ASTM F 567 and more stringent requirements indicated.
a. Install fencing on established boundary lines inside property line.

D. Chain-Link Fence Installation
1. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.
2. Post Setting: Set posts in concrete **OR** with mechanical anchors **OR** by mechanically driving into soil, **as directed**, at indicated spacing into firm, undisturbed soil.
a. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
b. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
1) Exposed Concrete: Extend 2 inches (50 mm) above grade; shape and smooth to shed water.
2) Concealed Concrete: Top 2 inches (50 mm) below grade as indicated on Drawings to allow covering with surface material.
3) Posts Set into Concrete in Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout **OR** anchoring cement, **as directed**, mixed and placed to comply with anchoring material manufacturer's written instructions, and finished sloped to drain water away from post.
4) Posts Set into Voids in Concrete: Form or core drill holes not less than 5 inches (125 mm) deep and 3/4 inch (20 mm) larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with

nonshrink, nonmetallic grout **OR** anchoring cement, **as directed**, mixed and placed to comply with anchoring material manufacturer's written instructions, and finished sloped to drain water away from post.

c. Mechanically Driven Posts: Drive into soil to depth of 30 inches (762 mm) **OR** 36 inches (914 mm), **as directed**. Protect post top to prevent distortion.

3. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more **OR** 30 degrees or more **OR** as indicated on Drawings, **as directed**.
4. Line Posts: Space line posts uniformly at 96 inches (2440 mm) **OR** 10 feet (3 m), **as directed**, o.c.
5. Post Bracing and Intermediate Rails: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Diagonally brace terminal posts to adjacent line posts with truss rods and turnbuckles. Install braces at end and gate posts and at both sides of corner and pull posts.
   a. Locate horizontal braces at midheight of fabric 72 inches (1830 mm) or higher, on fences with top rail and at two-third fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.
6. Tension Wire: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch- (3.05-mm-) diameter hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches (610 mm) o.c. Install tension wire in locations indicated before stretching fabric. Provide horizontal tension wire at the following locations:
   a. Extended along top **OR** bottom **OR** top and bottom, **as directed**, of fence fabric. Install top tension wire through post cap loops. Install bottom tension wire within 6 inches (152 mm) of bottom of fabric and tie to each post with not less than same diameter and type of wire.
   b. Extended along top of barbed wire arms **OR** extended posts, **as directed**, and top of fence fabric for supporting barbed tape.
   c. As indicated.
7. Top Rail: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.
8. Intermediate and Bottom Rails: Install and secure to posts with fittings.
9. Chain-Link Fabric: Apply fabric to outside **OR** inside, **as directed**, of enclosing framework. Leave 1 inch (25.4 mm) **OR** 2 inches (50 mm), **as directed**, between finish grade or surface and bottom selvage unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.
10. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than 15 inches (380 mm) o.c.
11. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at one end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric per ASTM F 626. Bend ends of wire to minimize hazard to individuals and clothing.
    a. Maximum Spacing: Tie fabric to line posts at 12 inches (300 mm) o.c. and to braces at 24 inches (610 mm) o.c.
12. Fasteners: Install nuts for tension bands and carriage bolts on the side of the fence opposite the fabric side. Peen ends of bolts or score threads to prevent removal of nuts, **as directed**.
13. Privacy Slats: Install slats in direction indicated, securely locked in place.
    a. Vertically **OR** Horizontally, **as directed**, for privacy factor of 70 to 75.
       OR
       Diagonally, for privacy factor of 80 to 85.
       OR
       Direction and privacy factor, **as directed**, as indicated.

14. Barbed Wire: Install barbed wire uniformly spaced, angled toward security side of fence **OR** as indicated on Drawings, **as directed**. Pull wire taut, install securely to extension arms, and secure to end post or terminal arms.
15. Barbed Tape: Comply with ASTM F 1911. Install barbed tape uniformly in configurations indicated and fasten securely to prevent movement or displacement.

E. Gate Installation
1. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

F. Gate Operator Installation
1. General: Install gate operators according to manufacturer's written instructions, aligned and true to fence line and grade.
2. Excavation for Support Posts **OR** Pedestals **OR** Equipment Bases/Pads, **as directed**: Hand-excavate holes for bases/pads, in firm, undisturbed soil to dimensions and depths and at locations as required by gate-operator component manufacturer's written instructions and as indicated.
3. Vehicle Loop Detector System: Cut grooves in pavement and bury **OR** Bury, **as directed**, and seal wire loop according to manufacturer's written instructions. Connect to equipment operated by detector.
4. Comply with NFPA 70 and manufacturer's written instructions for grounding of electric-powered motors, controls, and other devices.

G. Grounding And Bonding
1. Fence Grounding: Install at maximum intervals of 1500 feet (450 m), **as directed**, except as follows:
   a. Fences within 100 Feet (30 m) of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet (225 m), **as directed**.
      1) Gates and Other Fence Openings: Ground fence on each side of opening.
         a) Bond metal gates to gate posts.
         b) Bond across openings, with and without gates, except openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches (460 mm) below finished grade.
2. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet (45 m) on each side of crossing.
3. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2 unless otherwise indicated.
4. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches (150 mm) below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at the grounding location, including the following:
   a. Make grounding connections to each barbed wire strand with wire-to-wire connectors designed for this purpose.
   b. Make grounding connections to each barbed tape coil with connectors designed for this purpose.
5. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.
6. Connections: Make connections to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
   a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
   b. Make connections with clean, bare metal at points of contact.
   c. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.

d. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

7. Bonding to Lightning Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning protection down conductor or lightning protection grounding conductor complying with NFPA 780.

H. Field Quality Control
1. Grounding-Resistance Testing: Engage a qualified testing agency to perform tests and inspections.
a. Grounding-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure grounding resistance no fewer than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural grounding resistance. Perform tests by two-point method according to IEEE 81.
b. Excessive Grounding Resistance: If resistance to grounding exceeds specified value, notify the Owner promptly. Include recommendations for reducing grounding resistance and a proposal to accomplish recommended work.
c. Report: Prepare test reports certified by a testing agency of grounding resistance at each test location. Include observations of weather and other phenomena that may affect test results.

I. Adjusting
1. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.
2. Automatic Gate Operator: Energize circuits to electrical equipment and devices. Adjust operators, controls, safety devices, alarms, **as directed**, and limit switches.
a. Hydraulic Operator: Purge operating system, adjust pressure and fluid levels, and check for leaks.
b. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
c. Test and adjust controls, alarms, **as directed**, and safeties. Replace damaged and malfunctioning controls and equipment.
3. Lubricate hardware, gate operator, **as directed**, and other moving parts.

J. Demonstration
1. Train the Owner's personnel to adjust, operate, and maintain chain-link fences and gates.

END OF SECTION 32 31 11 00

SECTION 32 31 13 13 - HIGH-SECURITY CHAIN-LINK FENCES AND GATES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for high-security chain-link fences and gates. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. High-security chain-link fences.
b. Gates: Motor operated, horizontal slide and swing.

C. Performance Requirements
1. Delegated-Design Submittal: For chain-link fences and gate framework indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Structural Performance: Chain-link fences and gate framework shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to ASCE/SEI 7:
a. Minimum Post Size: Determine according to ASTM F 1043 for framework up to 12 feet (3.66 m) high, and post spacing not to exceed 10 feet (3 m) for Material Group IA, ASTM F 1043, Schedule 40 steel pipe **OR** Group IC, electric-resistance-welded round steel pipe, **as directed**.
OR
Minimum Post Size and Maximum Spacing: Provide line posts of size and in spacing indicated, but not less than sizes and spacings determined according to ASTM F 1916, including Appendix **OR** CLFMI WLG 2445, **as directed**, based on mesh size and pattern specified and the following:
1) Wind Loads: Determine design wind loads applicable to Project from basic wind speed and exposure category according to CLFMI WLG 2445.
2) Exposure Category: B **OR** C **OR** D, **as directed**.
3) Fence Height: 10 feet (3 m).
4) Material Group: IA, ASTM F 1043, Schedule 40 steel pipe **OR** IC, electric-resistance-welded round steel pipe, **as directed**.
b. Fabric Tension: Provide fences in which fabric deflections do not exceed those indicated in Table X1.1 of ASTM F 1916 when tested by applying a 30-lbf (133-N) force at midpoint between rails and horizontally between posts for every eighth lower panel along the fence line.
c. Fence Post Rigidity: Provide fences in which post deflections do not exceed 3/4 inch (19 mm) when tested according to ASTM F 1916 by applying a 50-lbf (222-N) force at midheight of every eighth post along the fence line.
3. Lightning Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

D. Submittals
1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for chain-link fences and gates, **as directed**.
a. Fence and gate posts, rails, and fittings.
b. Chain-link fabric, reinforcements, and attachments.
c. Accessories: Barbed wire **OR** Barbed tape, **as directed**.

d. Gates and hardware.
e. Gate Operator: Show locations and details for installing operator components, switches, and controls. Indicate motor size, electrical characteristics, drive arrangement, mounting, and grounding provisions.
f. Wiring Diagrams: For power, signal, and control wiring.

2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work. Show accessories, hardware, gate operation, and operational clearances.
   a. Gate Operator: Show locations and details for installing operator components, switches, and controls. Indicate motor size, electrical characteristics, drive arrangement, mounting, and grounding provisions.
   b. Wiring Diagrams: For power, signal, and control wiring.
3. Samples: Prepared on Samples of size indicated below:
   a. Polymer-Coated Components: In 6-inch (150-mm) lengths for components and on full-sized units for accessories.
4. Delegated-Design Submittal: For chain-link fences and gate framework indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
5. Qualification Data: For qualified professional engineer **OR** testing agency **OR** factory-authorized service representative, **as directed**.
6. Product Certificates: For each type of chain-link fence, operator, **as directed**, and gate, from manufacturer.
7. Product Test Reports: For framing strength according to ASTM F 1043.
8. Field quality-control reports.
9. Soil sterilization certificate of treatment stating materials and quantities used, and date of application.
10. Operation and Maintenance Data: For the following to include in emergency, operation, and maintenance manuals:
    a. Polymer finishes.
    b. Gate hardware.
    c. Gate operator.
11. Warranty: Sample of special warranty.

E. Quality Assurance
1. Testing Agency Qualifications: For testing fence grounding. Member company of NETA or an NRTL **OR** one who meets the requirements necessary for certification, **as directed**.
   a. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing **OR** one who meets the requirements necessary for certification, **as directed**.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Emergency Access Requirements: Comply with requirements of authorities having jurisdiction for automatic gate operators serving as a required means of access.
4. Preinstallation Conference: Conduct conference at Project site.

F. Project Conditions
1. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

G. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer **OR** Installer, **as directed**, agrees to repair or replace components of high-security chain-link fences and gates that fail in materials or workmanship within specified warranty period.
   a. Failures include, but are not limited to, the following:
      1) Deflection of fence fabric beyond design limits.

2) Deterioration of metals, metal finishes, and other materials beyond normal weathering.
3) Faulty operation of gate operators and controls.

b. Warranty Period: Five **OR** 15, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Chain-Link Fence Fabric

1. Chain-Link Fence Fabric: Provide fabric in one **OR** two, **as directed**,-piece heights measured between top and bottom of outer edge of selvage. Comply with CLFMI Product Manual and with requirements indicated below:
   a. Fabric Height: As indicated on Drawings **OR** As directed.
      1) Steel Wire Fabric: Wire with a diameter of 0.192 inch (4.88 mm) **OR** 0.148 inch (3.76 mm) **OR** 0.120 inch (3.05 mm) **OR** 0.113 inch (2.87 mm), **as directed**.
         a) Mesh Size: 2 inches (51 mm) **OR** 1 inch (25.4 mm) **OR** 3/8 inch (9.5 mm), **as directed**.
   b. Fabric Heights and Overlap: As indicated on Drawings **OR** As directed.
      1) Steel Wire Lower Fabric: Wire with a diameter of 0.192 inch (4.88 mm) **OR** 0.148 inch (3.76 mm) **OR** 0.120 inch (3.05 mm) **OR** 0.113 inch (2.87 mm), **as directed**.
         a) Mesh Size: 2 inches (51 mm) **OR** 1 inch (25.4 mm) **OR** 3/8 inch (9.5 mm), **as directed**.
      2) Steel Wire Upper Fabric: Wire with a diameter of 0.120 inch (3.05 mm).
         a) Mesh Size: 3/8 inch (9.5 mm).
   c. Aluminum-Coated Fabric: ASTM A 491, Type I, 0.40 oz./sq. ft. (122 g/sq. m) **OR** 0.35 oz./sq. ft. (107 g/sq. m) **OR** 0.30 oz./sq. ft. (92 g/sq. m), **as directed**.
   d. Zinc-Coated Fabric: ASTM A 392, Type II, Class 1, 1.2 oz./sq. ft. (366 g/sq. m) **OR** Class 2, 2.0 oz./sq. ft. (610 g/sq. m), **as directed**, with zinc coating applied before **OR** after, **as directed**, weaving.
   e. Zn-5-Al-MM Aluminum-Mischmetal-Coated Fabric: ASTM F 1345, Type III, Class 2, 1.0 oz./sq. ft. (305 g/sq. m).
   f. Polymer-Coated Fabric: ASTM F 668, Class 2b over aluminum **OR** zinc **OR** Zn-5-Al-MM-alloy, **as directed**,-coated steel wire.
      1) Color: Dark green **OR** Olive green **OR** Brown **OR** Black **OR** As selected by the Owner from manufacturer's full range, **as directed**, complying with ASTM F 934.
   g. Coat selvage ends of fabric that is metallic coated before the weaving process with manufacturer's standard clear protective coating.
   h. Selvage: Twisted and barbed top and bottom.

B. Security Fence Framing

1. Posts and Rails: Comply with ASTM F 1043 for framing, including rails, braces, and line; terminal; and corner posts.
   a. Fence Height: 96 inches (2440 mm) **OR** 12 feet (3.66 m) **OR** As indicated on Drawings, **as directed**.
   b. Heavy **OR** Light, **as directed**, Industrial Strength: Material Group IA, round steel pipe, Schedule 40 **OR** Group IC, round steel pipe, electric resistance-welded pipe, **as directed**.
      1) Line Post: 2.375 inches (60 mm) in diameter **OR** 2.875 inches (73 mm) in diameter **OR** 4 inches (100-mm) in diameter **OR** 6.625 inches (168 mm) in diameter **OR** 8.625 inches (168 mm) in diameter **OR** 2.25 by 1.70 inches (67 by 43 mm) **OR** 3.25 by 2.50 inches (83 by 64 mm), **as directed**.
      2) End, Corner, and Pull Post: 2.875 inches (73 mm) in diameter **OR** 4.0 inches (102 mm) in diameter **OR** 6.625 inches (168 mm) in diameter **OR** 8.625 inches (168 mm) in diameter, **as directed**.
   c. Rail Members: Intermediate, top, and brace, **as directed**, rails complying with ASTM F 1043 for Heavy Industrial.
   d. Metallic Coating for Steel Framing:

1) Type A, consisting of not less than minimum 2.0-oz./sq. ft. (0.61-kg/sq. m) average zinc coating per ASTM A 123/A 123M or 4.0-oz./sq. ft. (1.22-kg/sq. m) zinc coating per ASTM A 653/A 653M.
2) Type B, zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. (0.27 kg/sq. m) of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film.
3) External, Type B, zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. (0.27 kg/sq. m) of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film. Internal, Type D, consisting of 81 percent, not less than 0.3-mil- (0.0076-mm-) thick, zinc-pigmented coating.
4) Type C, Zn-5-Al-MM alloy, consisting of not less than 1.8-oz./sq. ft. (0.55-kg/sq. m) coating.
5) Coatings: Any coating above.

e. Polymer coating over metallic coating.
1) Color: Match chain-link fabric **OR** Dark green **OR** Olive green **OR** Brown **OR** Black **OR** As selected from manufacturer's full range, **as directed**, complying with ASTM F 934.

C. Tension Wire
1. Metallic-Coated Steel Wire: 0.177-inch- (4.5-mm-) diameter, marcelled tension wire complying with ASTM A 817 and ASTM A 824, with the following metallic coating:
a. Type I, aluminum coated (aluminized).
b. Type II, zinc coated (galvanized) by hot-dip **OR** electrolytic, **as directed**, process, with Class 5 minimum coating weight of not less than 2.0 oz./sq. ft. (610 g/sq. m) of uncoated wire surface.
2. Polymer-Coated Steel Wire: 0.177-inch- (4.5-mm-) diameter, tension wire complying with ASTM F 1664, Class 1 **OR** Class 2a **OR** Class 2b, **as directed**, over aluminum **OR** zinc **OR** Zn-5-Al-MM-alloy, **as directed**,-coated steel wire.
a. Color: Match chain-link fabric **OR** Dark green **OR** Olive green **OR** Brown **OR** Black **OR** As selected from manufacturer's full range, **as directed**, complying with ASTM F 934.

D. Swing Gates
1. General: Comply with ASTM F 900 for gate posts and single **OR** double, **as directed**, swing gate types. Provide automated vehicular gates that comply with ASTM F 2200, **as directed**.
a. Gate Leaf Width: 36 inches (914 mm) **OR** As indicated, **as directed**.
b. Gate Fabric Height: 72 inches (1830 mm) or less **OR** More than 72 inches (1830 mm) **OR** As indicated, **as directed**.
2. Pipe and Tubing:
a. Zinc-Coated Steel: Comply with ASTM F 1043 and ASTM F 1083; protective coating and finish to match fence framing **OR** manufacturer's standard protective coating and finish, **as directed**.
b. Aluminum: Comply with ASTM B 429/B 429M; mill **OR** manufacturer's standard, **as directed**, finish.
c. Gate Post Size and Weight: Not less than required by ASTM F 900 **OR** ASTM F 1916, **as directed**.
d. Gate Posts: Round tubular steel **OR** Rectangular tubular steel **OR** Round tubular aluminum **OR** Rectangular tubular aluminum, **as directed**.
e. Gate Frames and Bracing: Round tubular steel **OR** Rectangular tubular steel **OR** Round tubular aluminum **OR** Rectangular tubular aluminum, **as directed**.
3. Frame Corner Construction: Welded **OR** Assembled with corner fittings, **as directed**, and 3/8-inch- (9.5-mm-) diameter, adjustable truss rods for panels 5 feet (1.52 m) or wider.
4. Extended Gate Posts and Frame Members: Extend above top of chain-link fabric at both ends of gate frame 12 inches (300 mm) **OR** as indicated, **as directed**, as required to attach barbed wire **OR** tape, **as directed**, assemblies.
5. Provide separate isolated gate frame according to ASTM F 1916 and as indicated.

a. Separation between Hinge and Latch Post and Fence Termination Post: 2 inches (51 mm) minimum, 2-1/2 inches (63.5 mm) maximum.

6. Hardware: Comply with ASTM F 1916.
   a. Hinges: 180-degree inward **OR** 180-degree outward **OR** 360-degree inward and outward, **as directed**, swing.
   b. Latches permitting operation from one side **OR** both sides, **as directed**, of gate with provision for padlocking accessible from both sides of gate, **as directed-**.
   c. Padlock and Chain: the Owner furnished.
   d. Lock: Manufacturer's standard, **as directed**, internal device furnished in lieu of gate latch, **as directed**.
   e. Closer: Manufacturer's standard, **as directed**.
   f. For gates 14 feet (4.27 m) and higher, add locking device to transom.

E. Horizontal-Slide Gates
1. General: Comply with ASTM F 1184 for gate posts and single **OR** double, **as directed**, sliding gate types. Provide automated vehicular gates that comply with ASTM F 2200, **as directed**.
   a. Classification: Type I Overhead Slide.
      1) Gate Leaf Width: As indicated.
      2) Gate Fabric Height: 72 inches (1830 mm) or less **OR** More than 72 inches (1830 mm) **OR** As indicated, **as directed**.
   b. Classification: Type II Cantilever Slide, Class 1 with external **OR** Class 2 with internal, **as directed**, roller assemblies.
      1) Gate Frame Width and Height: 48 inches (1200 mm) wide or less by 72 inches (1830 mm) high or less **OR** More than 48 inches (1200 mm) wide by any height **OR** As indicated, **as directed**.
2. Pipe and Tubing:
   a. Zinc-Coated Steel: Protective coating and finish to match fence framing **OR** Manufacturer's standard protective coating and finish, **as directed**.
   b. Aluminum: Comply with ASTM B 429/B 429M; mill **OR** manufacturer's standard, **as directed**, finish.
   c. Gate Post Size and Weight: Not less than required by ASTM F 1184 **OR** ASTM F 1916, **as directed**.
   d. Gate Frames and Bracing: Round tubular steel **OR** Rectangular tubular steel **OR** Round tubular aluminum **OR** Rectangular tubular aluminum, **as directed**.
3. Frame Corner Construction: Welded **OR** Assembled with corner fittings, **as directed**, and 3/8-inch- (9.5-mm-) diameter, adjustable truss rods for panels 5 feet (1.52 m) or wider.
4. Extended Gate Posts and Frame Members: Extend above top of chain-link fabric at both ends of gate frame 12 inches (300 mm) **OR** as indicated, **as directed**, as required to attach barbed wire **OR** tape, **as directed**, assemblies.
5. Overhead Track Assembly: Manufacturer's standard track, with overhead framing supports, bracing, and accessories, engineered to support size, weight, width, operation, and design of gate and roller assemblies.
6. Hardware:
   a. Latches permitting operation from one side **OR** both sides, **as directed**, of gate with provision for padlocking accessible from both sides of gate, **as directed**.
   b. Padlock and Chain: the Owner furnished.
   c. Lock: Manufacturer's standard, **as directed**, internal device furnished in lieu of gate latch, **as directed**.
   d. Hangers, roller assemblies, and stops fabricated from galvanized steel **OR** galvanized malleable iron **OR** mill-finished Grade 319 aluminum-alloy casting with stainless-steel fasteners, **as directed**.

F. Fittings
1. General: Comply with ASTM F 626.
2. Post Caps: Provide for each post.
   a. Provide line post caps with loop to receive tension wire or top rail.

3. Rail and Brace Ends: For each gate, corner, pull, and end post.
4. Rail Fittings: Provide the following:
   a. Top-Rail Sleeves: Pressed steel or round steel tubing not less than 6 inches (152 mm) long.
   b. Rail Clamps: Line and corner boulevard clamps for connecting intermediate and bottom, **as directed**, rails in the fence line to line posts.
5. Tension and Brace Bands, Tension Bars, and Truss Rod Assemblies: Comply with ASTM F 2611.
6. Barbed Wire Arms: Pressed steel or cast iron **OR** Aluminum, **as directed**, with clips, slots, or other means for attaching strands of barbed wire, and means for attaching to posts **OR** integral with post cap, **as directed**; for each post unless otherwise indicated, and as follows:
   a. Provide line posts with arms that accommodate top rail or tension wire.
   b. Provide corner arms at fence corner posts, unless extended posts are indicated.
   c. Type I, single slanted arm.
   d. Type II, single vertical arm.
   e. Type III, V-shaped arm.
   f. Type IV, A-shaped arm.
   g. Bolts or rivets for connection to post.
7. Tie Wires, Clips, and Fasteners: Comply with ASTM F 626 and ASTM F 1916.
   a. High-Security Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, complying with the following:
      1) Metallic-Coated Steel: 0.148-inch- (3.76-mm-) **OR** 0.192-inch- (4.88-mm-), **as directed**, diameter wire; zinc **OR** aluminum, **as directed**, coating.
      2) Stainless steel.
8. Power-Driven Fabric Fasteners: Comply with ASTM F 1916.
9. Finish:
   a. Metallic Coating for Pressed Steel or Cast Iron: Not less than 1.2 oz. /sq. ft. (366 g/sq. m) of zinc.
      1) Polymer coating over metallic coating.
   b. Aluminum: Mill finish.

G. Barbed Wire
1. Steel Barbed Wire: Comply with ASTM A 121, High Security Grade, for two-strand barbed wire; 0.099-inch- (2.51-mm-) diameter line wire with 0.080-inch- (2.03-mm-) diameter, four-point round barbs spaced not more than 3 inches (76 mm) o.c.
   a. Aluminum Coating: Type A.
2. Polymer-Coated, Galvanized-Steel Barbed Wire: Comply with ASTM F 1665, Type II, for two-strand barbed wire; 0.080-inch- (2.03-mm-) diameter line wire with 0.080-inch- (2.03-mm-) diameter, four-point round aluminum-alloy **OR** galvanized-steel, **as directed**, barbs spaced not more than 3 inches (76 mm) o.c.
   a. Polymer Coating: Class 1 **OR** Class 2a **OR** Class 2b, **as directed**, over aluminum **OR** zinc **OR** Zn-5-Al-MM-alloy, **as directed**,-coated steel wire.
      1) Color: Match chain-link fabric **OR** Dark green **OR** Olive green **OR** Brown **OR** Black **OR** As selected from manufacturer's full range, **as directed**, complying with ASTM F 934.

H. Barbed Tape
1. Wire-Reinforced Tape: ASTM F 1910; with four-point, needle-sharp barbs permanently cold clenched around a core wire.
   a. Core Wire: High-tensile-strength, zinc-coated steel or stainless steel.
2. Clips: Stainless steel, 0.065 inch (1.65 mm) thick by 0.375 inch (9.5 mm) wide; capable of withstanding a minimum 150-lbf (667-N) pull load to limit extension of coil, resulting in a concertina pattern when deployed.
3. Tie Wires: Stainless steel, 0.065 inch (1.65 mm) in diameter.

4. Fabrication: Continuous coils of barbed tape as defined in ASTM F 1379 for the following characteristics:
   a. Configuration: Single **OR** Double, **as directed**, coil.
   b. Style: Helical **OR** Concertina, **as directed**, pattern.
   c. Coil Diameter(s): 18 inches (457 mm) **OR** 24 inches (610 mm) **OR** 24-inch (610-mm) inner coil and 30-inch (762-mm) outer coil **OR** As indicated on Drawings, **as directed**.
   d. Coil Loop Spacing(s): 12 inches (305 mm) **OR** Manufacturer's standard **OR** As indicated on Drawings, **as directed**.
   e. Barb Length Classification: Long, 1.2-inch (30.5-mm) **OR** Medium, 0.4-inch (10.2-mm) **OR** Short, 0.1875-inch (4.76-mm), **as directed**, barb.
   f. Barb Spacing: 4 inches (102 mm) o.c.
   g. Barb Set: Straight **OR** Offset **OR** Manufacturer's standard, **as directed**.
5. Ground Barrier Stakes: 3/8-inch- (9.5-mm-) diameter galvanized reinforcing bar, 18 inches (457 mm) long with 180-degree end hook 3-1/2 inches (89 mm) long.

I. Gate Operators
1. General: Provide factory-assembled automatic operating system designed for gate size, type, weight, and operation frequency. Provide operation control system with characteristics suitable for Project conditions, with remote-control stations, safety devices, and weatherproof enclosures; coordinate electrical requirements with building electrical system.
   a. Provide operator designed so motor may be removed without disturbing limit-switch adjustment and without affecting auxiliary emergency operator.
   b. Provide operator with UL approval **OR** UL-approved components, **as directed**.
   c. Provide electronic components with built-in troubleshooting diagnostic feature.
   d. Provide unit designed and wired for both right-hand/left-hand opening, permitting universal installation.
2. Comply with NFPA 70.
3. UL Standard: Manufacturer and label gate operators to comply with UL 325.
4. Motor Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, within installed environment, with indicated operating sequence, and without exceeding nameplate rating or considering service factor. Comply with NEMA MG 1 and the following:
   a. Voltage: 12-V dc **OR** 120 V **OR** 208-220 V **OR** NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected, **as directed**.
   b. Horsepower: 1/4 **OR** 1/3 **OR** 3/4, **as directed**.
   c. Enclosure: Open dripproof **OR** Totally enclosed **OR** Manufacturer's standard, **as directed**.
   d. Duty: Continuous duty at ambient temperature of 105 deg F (40 deg C) and at altitude of 3300 feet (1005 m) above sea level.
   e. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.
   f. Phase: One **OR** Polyphase, **as directed**.
5. Gate Operators: Gate **OR** Equipment base/pad **OR** Pedestal post **OR** In ground, **as directed**, mounted and as follows:
   a. Hydraulic Swing **OR** Slide, **as directed**, Gate Operators:
      1) Duty: Medium **OR** Heavy, **as directed**.
      2) Gate Speed: Minimum 45 feet (13.7 m) **OR** 60 feet (18.2 m), **as directed**, per minute.
      3) Maximum Gate Weight: 800 lb (363 kg).
      4) Frequency of Use: 10 cycles per hour **OR** 25 cycles per hour **OR** Continuous duty, **as directed**.
      5) Operating Type: Wheel and rail drive with manual release, **as directed**.
      6) Hydraulic Fluid: Of viscosity required for gate operation at ambient temperature range for Project.
      7) Locking: Hydraulic in both directions.
      8) Heater: Manufacturer's standard track and roller heater with thermostatic control.
   b. Mechanical Swing **OR** Slide, **as directed**, Gate Operators:
      1) Duty: Medium **OR** Heavy **OR** Maximum security, **as directed**.

2) Gate Speed: Minimum 45 feet (13.7 m) per minute **OR** 60 feet (18.2 m) per minute **OR** variable speed, **as directed**.
3) Maximum Gate Weight: 800 lb (363 kg) **OR** 3000 lb (1360 kg), **as directed**.
4) Frequency of Use: 10 cycles per hour **OR** 25 cycles per hour **OR** 60 cycles per hour **OR** Continuous duty, **as directed**.
5) Operating Type: Crank arm **OR** Enclosed **OR** Wheel and rail drive **OR** Roller chain, **as directed**, with manual release, **as directed**.
6) Drive Type: Enclosed worm gear and chain-and-sprocket, **as directed**, reducers, roller-chain drive.
OR
Drive Type: V-belt and worm gear **OR** chain-and-sprocket, **as directed**, reducers, roller-chain drive.

6. Remote Controls: Electric controls separated from gate and motor and drive mechanism, with NEMA ICS 6, Type 1 **OR** NEMA ICS 6, Type 4, **as directed**, enclosure for surface **OR** recessed or flush **OR** equipment base/pad **OR** pedestal, **as directed**, mounting and with space for additional optional equipment. Provide the following remote-control device(s):
a. Control Station: Keyed, two **OR** three, **as directed**,-position switch, located remotely from gate. Provide two keys per station.
OR
Control Station: Momentary contact, single **OR** three, **as directed**,-button operated, located remotely from gate. Key switch to lock out open and close buttons, **as directed**.
1) Function: Open, stop, **as directed**, and close.
b. Card Reader: Functions only when authorized card is presented. Programmable, magnetic multiple **OR** single, **as directed**,-code system, permitting four different access time periods, **as directed**; face-lighted unit fully visible at night, **as directed**.
1) Reader Type: Touch plate **OR** Swipe **OR** Insertion **OR** Proximity, **as directed**.
2) Features: Timed anti-passback **OR** Limited-time usage **OR** Capable of monitoring and auditing gate activity, **as directed**.
c. Digital Keypad Entry Unit: Multiple-code capability **OR** Multiple-programmable code capability, **as directed**, of not less than five **OR** 500 **OR** 2500, **as directed**, possible individual codes, consisting of one- to seven **OR** four **OR** five, **as directed**,-digit codes and permitting four different access time periods, **as directed**.
1) Features: Timed anti-passback **OR** Limited-time usage **OR** Capable of monitoring and auditing gate activity, **as directed**.
2) Face-lighted unit with metal-keyed **OR** keyless-membrane, **as directed**, keypad fully visible at night.
d. Radio Control: Digital system consisting of code-compatible universal receiver for each gate, located where indicated, with remote antenna with coaxial cable and mounting brackets designed to operate gates. Provide one **OR** two, **as directed**, programmable transmitter(s) with multiple-code capability permitting validating or voiding of not less than 1000 **OR** 10,000, **as directed**, codes per channel configured for the following functions:
1) Transmitters: Single **OR** Three, **as directed**,-button operated, with open **OR** open and close, **as directed**, function.
2) Channel Settings: Two **OR** Three **OR** Four, **as directed**, independent channel settings controlling separate receivers for operating more than one gate from each transmitter.
e. Telephone Entry System: Hands-free voice-communication system for connection to building telephone system with digital-entry code activation of gate operator and auxiliary keypad entry, **as directed**.
1) System: Designed to be wired to same line with telephone.
OR
Multiunit System: Designed to be wired to a dedicated telephone line, with capacity to access 20 **OR** 100, **as directed**, telephones and with electronic directory, **as directed**.

f. Vehicle Loop Detector: System including automatic closing timer with adjustable time delay before closing, timer cut-off switch, **as directed**, and loop detector designed to open and close gate **OR** hold gate open until traffic clears **OR** reverse gate, **as directed**. Provide electronic detector with adjustable detection patterns, adjustable sensitivity and frequency settings, and panel indicator light designed to detect presence or transit of a vehicle over an embedded loop of wire and to emit a signal activating the gate operator. Provide number of loops consisting of multiple strands of wire, number of turns, loop size, and method of placement at location shown on Drawings, as recommended in writing by detection system manufacturer for function indicated.

1) Loop: Wire, in size indicated for field assembly, for pave-over **OR** saw-cut with epoxy-grouted, **as directed**, installation.

OR

Loop: Factory preformed in size indicated; style for pave-over **OR** saw-cut with epoxy-grouted, **as directed**, installation.

g. Vehicle Presence Detector: System including automatic closing timer with adjustable time delay before closing, timer cut-off switch, **as directed**, and presence detector designed to open and close gate **OR** hold gate open until traffic clears **OR** reverse gate, **as directed**. Provide retroreflective **OR** emitter/receiver, **as directed**, detector with adjustable detection zone pattern and sensitivity, designed to detect presence or transit of a vehicle in gate pathway when an infrared beam in zone pattern is interrupted, and to emit a signal activating the gate operator.

7. Obstruction Detection Devices: Provide each motorized gate with automatic safety sensor(s). Activation of sensor(s) causes operator to immediately function as follows:
   a. Action: Reverse gate in both opening and closing cycles and hold until clear of obstruction **OR** Stop gate in opening cycle and reverse gate in closing cycle and hold until clear of obstruction, **as directed**.
   b. Internal Sensor: Built-in torque or current monitor senses gate is obstructed.
   c. Sensor Edge: Contact-pressure-sensitive safety edge, profile, and sensitivity designed for type of gate and component indicated, in locations as follows. Connect to control circuit using take-up cable reel **OR** self-coiling cable **OR** gate edge transmitter and operator receiver system, **as directed**.
      1) Along entire gate leaf leading edge (for swing gates and slide gates).
      2) Along entire gate leaf trailing edge (for slide gates).
      3) Across entire gate leaf bottom edge (for vehicular swing and slide gates complying with UL 325 or to suit Project; consider retaining for pedestrian gates).
      4) Along entire length of gate posts (for slide gates; revise for sensor edge at pinch point post of swing gates).
      5) Along entire length of gate guide posts (for Type II Cantilever Slide, Class 1 gates).
      6) Where indicated on Drawings.
   d. Photoelectric/Infrared Sensor: System designed to detect an obstruction in gate's path when infrared beam in the zone pattern is interrupted.
8. Limit Switches: Adjustable switches, interlocked with motor controls and set to automatically stop gate at fully retracted and fully extended positions.
9. Emergency Release Mechanism: Quick-disconnect release of operator drive system of the following type of mechanism, permitting manual operation if operator fails. Design system so control circuit power is disconnected during manual operation.
   a. Type: Integral fail-safe release, allowing gate to be pushed open without mechanical devices, keys, cranks, or special knowledge **OR** Mechanical device, key, or crank-activated release, **as directed**.
10. Operating Features:
   a. Digital Microprocessor Control: Electronic programmable means for setting, changing, and adjusting control features with capability of monitoring and auditing gate activity, **as directed**. Provide unit that is isolated from voltage spikes and surges.
   b. System Integration: With controlling circuit board capable of accepting any type of input from external devices.
   c. Master/Slave Capability: Control stations designed and wired for gate pair operation.

d. Automatic Closing Timer: With adjustable time delay before closing and timer cut-off switch, **as directed**.
e. Open Override Circuit: Designed to override closing commands.
f. Reversal Time Delay: Designed to protect gate system from shock load on reversal in both directions.
g. Maximum Run Timer: Designed to prevent damage to gate system by shutting down system if normal time to open gate is exceeded.
h. Clock Timer: 24-hour **OR** Seven-day, **as directed**, programmable for regular events.

11. Accessories:
a. Warning Module: Audio **OR** Visual, **as directed**, constant **OR** strobe, **as directed**,-light alarm sounding three to five seconds in advance of gate operation and continuing until gate stops moving; compliant with the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines.
b. Battery Backup System: Battery-powered drive and access-control system, independent of primary drive system.
1) Fail Safe: Gate opens and remains open until power is restored.
2) Fail Secure: Gate cycles on battery power, then fail safe when battery is discharged.
c. External electric-powered solenoid **OR** magnetic, **as directed**, lock with delay timer allowing time for lock to release before gate operates.
d. Fire **OR** Postal, **as directed**, box.
e. Fire strobe **OR** siren, **as directed**, sensor.
f. Intercom System: As required to meet Project requirements.
g. Instructional, Safety, and Warning Labels and Signs: According to UL 325 **OR** Manufacturer's standard for components and features specified **OR** As indicated on Drawings, **as directed**.
h. Equipment Bases/Pads: Precast concrete, depth not less than 12 inches (305 mm), dimensioned and reinforced according to gate operator component manufacturer's written instructions and as indicated on Drawings.

J. Grout And Anchoring Cement
1. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout, recommended in writing by manufacturer, for exterior applications.
2. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating and that is recommended in writing by manufacturer for exterior applications.

K. Fence Grounding
1. Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.
a. Material above Finished Grade: Copper **OR** Aluminum, **as directed**.
b. Material on or below Finished Grade: Copper.
c. Bonding Jumpers: Braided copper tape, 1 inch (25.4 mm) wide, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.
2. Connectors and Grounding Rods: Listed in UL 467.
a. Connectors for Below-Grade Use: Exothermic welded type.
b. Grounding Rods: Copper-clad steel, 5/8 by 96 inches (16 by 2440 mm).

L. Soil Sterilization
1. Soil Sterilant: Type approved by authorities having jurisdiction.
2. Polyethylene Sheeting: 6 mils (0.15 mm) thick, black, and serving as soil separation fabric.
3. Stone Ground Cover: 3/4- to 2-inch (19- to 51-mm) crushed stone or washed gravel.

1.3 EXECUTION

A. Examination
1. Examine areas and conditions, with Installer present, for compliance with requirements for a verified survey of property lines and legal boundaries, **as directed**, site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.
a. Do not begin installation before final grading is completed unless otherwise permitted by the Owner.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation
1. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet (152 m) or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

C. Installation, General
1. Install chain-link fencing to comply with ASTM F 567 **OR** ASTM F 1916, **as directed**, and more stringent requirements specified.
a. Install fencing on established boundary lines inside property line.

D. Chain-Link Fence Installation
1. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.
2. Post Setting: Set posts in concrete **OR** with mechanical anchors **OR** by mechanically driving into soil, **as directed**, at indicated spacing into firm, undisturbed soil.
a. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
b. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
1) Exposed Concrete: Extend 2 inches (51 mm) above grade or to same elevation as concrete grade beam, **as directed**; shape and smooth to shed water.
2) Concealed Concrete: Top 2 inches (51 mm) below grade as indicated on Drawings to allow covering with surface material.
3) Posts Set into Concrete in Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout **OR** anchoring cement, **as directed**, mixed and placed to comply with anchoring material manufacturer's written instructions, and finished sloped to drain water away from post.
4) Posts Set into Voids in Concrete: Form or core drill holes not less than 5 inches (127 mm) deep and 3/4 inch (19 mm) larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout **OR** anchoring cement, **as directed**, mixed and placed to comply with anchoring material manufacturer's written instructions, and finished sloped to drain water away from post.
3. Terminal Posts: Locate and install terminal end, corner, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more, at any abrupt change in grade, and at intervals not greater than 500 feet (152 m). For runs exceeding 500 feet (152 m), space pull posts an equal distance between corner or end posts.
4. Line Posts: Space line posts uniformly at 96 inches (2440 mm) **OR** 10 feet (3 m), **as directed**, o.c.
5. Post Bracing and Intermediate Rails: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Diagonally brace terminal posts to adjacent line posts with truss rods and turnbuckles. Install braces at end and gate posts and at both sides of corner and pull posts.

a. Locate horizontal braces at midheight of fabric 72 inches (1830 mm) or higher, on fences with top rail and at two-third fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.

6. Barbed Wire Arms: Bolt or rivet to top of post. Angle single arms away from approach side of fence.
7. Tension Wire: Install according to ASTM F 567 and ASTM F 1916, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch- (3.05-mm-) diameter hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches (610 mm) o.c. Install tension wire in locations indicated before stretching fabric. Provide horizontal tension wire at the following locations:
   a. Extended along top and bottom, **as directed**, of fence fabric. Install top tension wire through post cap loops. Install bottom tension wire within 6 inches (152 mm) of bottom of fabric and tie to each post with not less than same diameter and type of wire.
   b. Extended along top of barbed wire arms **OR** extended posts, **as directed**, and top of fence fabric for supporting barbed tape.
   c. As indicated.
8. Top Rail: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended by fencing manufacturer.
9. Bottom Rails: Install and secure to posts with fittings; anchor rail at midspan to concrete footing **OR** continuous grade beam, **as directed**.
10. Chain-Link Fabric: Apply fabric on the approach side of fence, inside of enclosing framework. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.
    a. Leave 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, between finish grade or surface and bottom selvage unless otherwise indicated.
    b. Where indicated, bury an 18-inch- (457-mm-) wide, polymer-coated fabric 12 inches (305 mm) into trench; overlap above-grade fabric 6 inches (152 mm) and secure to bottom rail with tie wires. Backfill and compact trench.
    c. Overlapping Fabric: At or between post or rail according to ASTM F 1916, with wire ties or steel strap method.
11. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than 15 inches (381 mm) o.c.
12. Tie Wires: Power-fastened or manually fastened ties configured to wrap a full 360 degrees around rail or post and a minimum of one complete diamond of fabric. Twist ends one and one-half machine twists or three full manual twists, and cut off protruding ends to preclude untwisting by hand.
    a. Maximum Spacing: Tie fabric to line posts at 12 inches (305 mm) o.c. and to braces at 24 inches (610 mm) o.c.
13. Power-Driven Fasteners: Fasten 0.192- or 0.148-inch (4.87- or 3.76-mm) wire fabric with 2- or 1-inch (51- or 25.4-mm) mesh size.
    a. Fasten fabric to line posts 12 inches (305 mm) o.c. and to braces 24 inches (610 mm) o.c.
14. Fasteners: Install nuts for tension bands and carriage bolts on the side of fence opposite the fabric side. Peen ends of bolts or score threads to prevent removal of nuts, **as directed**.
15. Barbed Wire: Install barbed wire uniformly spaced as indicated on Drawings **OR** as directed. Pull wire taut, install securely to extension arms, and secure to end post or terminal arms.
16. Barbed Tape: Comply with ASTM F 1911. Install barbed tape uniformly in configurations indicated and fasten securely to prevent movement or displacement.
17. Ground Barrier Stakes: Stake coils at 10 feet (3 m) o.c., driven to full depth.

E. Gate Installation
   1. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-

resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

F. Gate Operator Installation
1. General: Install gate operators according to manufacturer's written instructions, aligned and true to fence line and grade.
2. Excavation for Support Posts **OR** Pedestals **OR** Equipment Bases/Pads, **as directed**: Hand-excavate holes for bases/pads, in firm, undisturbed soil to dimensions and depths and at locations as required by gate operator component manufacturer's written instructions and as indicated.
3. Vehicle Loop Detector System: Cut grooves in pavement and bury **OR** Bury, **as directed**, and seal wire loop according to manufacturer's written instructions. Connect to equipment operated by detector.
4. Comply with NFPA 70 and manufacturer's written instructions for grounding of electric-powered motors, controls, and other devices.

G. Grounding And Bonding
1. Fence Grounding: Install at maximum intervals of 100 feet (30 m) except as follows:
   a. Gates and Other Fence Openings: Ground fence on each side of opening.
      1) Bond metal gates to gate posts.
      2) Bond across openings, with and without gates, except openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches (457 mm) below finished grade.
2. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet (45 m) on each side of crossing.
3. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2 unless otherwise indicated.
4. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches (152 mm) below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location, including the following:
   a. Make grounding connections to each barbed wire strand with wire-to-wire connectors designed for this purpose.
   b. Make grounding connections to each barbed tape coil with connectors designed for this purpose.
5. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.
6. Connections: Make connections to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
   a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
   b. Make connections with clean, bare metal at points of contact.
   c. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
   d. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
   e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
7. Bonding to Lightning Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning protection down conductor or lightning protection grounding conductor complying with NFPA 780.

H. Soil Sterilization
1. General: Comply with ASTM F 1916.
2. Apply sterilant after completing grounding and other below-grade electrical work along fence line and within zone between double-row chain-link fence installation.

3. Install soil separation fabric continuously between double-row chain-link fence installation, overlapping punctures and joints 6 inches (152 mm).
4. Lay continuous 3-inch- (75-mm-) deep bed of crushed stone or washed gravel over soil separation fabric.
5. Extend soil sterilization 4 feet (1.2 m) **OR** 6 feet (1.8 m), **as directed**, beyond outside and inside of fence.

I. Field Quality Control
1. Fabric Testing: Test fabric tension according to ASTM F 1916.
2. Fence Post Rigidity Testing: Test line posts for rigidity according to ASTM F 1916.
3. Grounding-Resistance Testing: Engage a qualified testing agency to perform tests and inspections.
   a. Grounding-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure grounding resistance no fewer than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural grounding resistance. Perform tests by two-point method according to IEEE 81.
   b. Excessive Grounding Resistance: If resistance to grounding exceeds specified value, notify the Owner promptly. Include recommendations for reducing grounding resistance and a proposal to accomplish recommended work.
   c. Report: Prepare test reports, certified by testing agency, of grounding resistance at each test location. Include observations of weather and other phenomena that may affect test results.

J. Adjusting
1. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.
2. Automatic Gate Operator: Energize circuits to electrical equipment and devices. Adjust operators, controls, safety devices, alarms, **as directed**, and limit switches.
   a. Hydraulic Operator: Purge operating system, adjust pressure and fluid levels, and check for leaks.
   b. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   c. Test and adjust controls, alarms, **as directed**, and safeties. Replace damaged and malfunctioning controls and equipment.
3. Lubricate hardware, gate operator, **as directed**, and other moving parts.

K. Demonstration
1. Train the Owner's personnel to adjust, operate, and maintain high-security chain-link fences and gates.

END OF SECTION 32 31 13 13

Task	Specification	Specification Description
32 31 13 13	01 22 16 00	No Specification Required
32 31 13 13	31 13 13 00	Tree Protection And Trimming
32 31 13 13	32 31 11 00	Chain-Link Fences And Gates

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SECTION 32 31 19 00 - ORNAMENTAL METAL FENCES AND GATES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of ornamental metal fences and gates. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
   a. Decorative metallic-coated steel tubular picket fences.
   b. Decorative metallic-coated steel wire fences.
   c. Decorative metallic-coated steel security fences.
   d. Decorative steel fences.
   e. Decorative aluminum fences.
   f. Swing gates.
   g. Horizontal-slide gates.
   h. Gate operators, including controls.

C. Performance Requirements
1. Lightning-Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

D. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For gates. Include plans, elevations, sections, details, and attachments to other work.
   a. Wiring Diagrams: For power, signal, and control wiring.
3. Samples: For each fence material and for each color specified.
   a. Provide Samples 12 inches (300 mm) in length for linear materials.
   b. Provide Samples 12 inches (300 mm) square for wire mesh, bar grating, and sheet or plate materials.
4. Welding certificates.
5. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for decorative metallic-coated steel tubular picket fences, including finish, indicating compliance with referenced standard and other specified requirements.
6. Maintenance Data: For gate operators to include in maintenance manuals.

E. Quality Assurance
1. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel **OR** AWS D1.2/D1.2M, "Structural Welding Code - Aluminum", **as directed**.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. UL Standard: Provide gate operators that comply with UL 325.
4. Emergency Access Requirements: Comply with requirements of authorities having jurisdiction for automatic gate operators on gates that must provide emergency access.
5. Preinstallation Conference: Conduct conference at Project site.

1.2 PRODUCTS

A. Aluminum
1. Aluminum, General: Provide alloys and tempers with not less than the strength and durability properties of alloy and temper designated in paragraphs below for each aluminum form required.
2. Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063-T5.
3. Tubing: ASTM B 429, Alloy 6063-T6.
4. Plate and Sheet: ASTM B 209 (ASTM B 209M), Alloy 6061-T6.
5. Die and Hand Forgings: ASTM B 247 (ASTM B 247M), Alloy 6061-T6.
6. Castings: ASTM B 26/B 26M, Alloy A356.0-T6.

B. Steel And Iron
1. Plates, Shapes, and Bars: ASTM A 36/A 36M.
2. Bars (Pickets): Hot-rolled, carbon steel complying with ASTM A 29/A 29M, Grade 1010.
3. Tubing: ASTM A 500, cold formed steel tubing.
4. Bar Grating: NAAMM MBG 531.
   a. Bars: Hot-rolled steel strip, ASTM A 1011/A 1011M, Commercial Steel, Type B.
   b. Wire Rods: ASTM A 510 (ASTM A 510M).
5. Uncoated Steel Sheet: Hot-rolled steel sheet, ASTM A 1011/A 1011M, Structural Steel, Grade 45 (Grade 310) or cold-rolled steel sheet, ASTM A 1008/A 1008M, Structural Steel, Grade 50 (Grade 340).
6. Galvanized-Steel Sheet: ASTM A 653/A 653M, structural quality, Grade 50 (Grade 340), with G90 (Z275) **OR** G60 (Z180), **as directed**, coating.
7. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, structural quality, Grade 50 (Grade 340), with AZ60 (AZM180) coating.
8. Castings: Either gray or malleable iron unless otherwise indicated.
   a. Gray Iron: ASTM A 48/A 48M, Class 30.
   b. Malleable Iron: ASTM A 47/A 47M.

C. Coating Materials
1. Shop Primers for Steel: Provide primers that comply with Division 09 Section(s) "Exterior Painting" OR "High-performance Coatings", **as directed**.
2. Epoxy Zinc-Rich Primer for Steel: Complying with MPI #20 and compatible with coating specified to be applied over it.
   a. Use primer with a VOC content of 420 g/L **OR** 400 g/L **OR** 340 g/L, **as directed**, or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Epoxy Primer for Galvanized Steel: Complying with MPI #101 and compatible with coating specified to be applied over it.
   a. Use primer with a VOC content of 420 g/L **OR** 400 g/L **OR** 300 g/L, **as directed**, or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
4. Epoxy Intermediate Coat: Complying with MPI #77 and compatible with primer and topcoat.
   a. Use product with a VOC content of 420 g/L **OR** 400 g/L **OR** 250 g/L, **as directed**, or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
5. Polyurethane Topcoat: Complying with MPI #72 and compatible with undercoat.
   a. Use product with a VOC content of 420 g/L **OR** 400 g/L **OR** 250 g/L, **as directed**, or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Miscellaneous Materials
1. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
   a. For aluminum, provide type and alloy as recommended by producer of metal to be welded and as required for strength and compatibility in fabricated items.
2. Concrete: Normal-weight, air-entrained, ready-mix concrete complying with requirements in Division 03 Section "Miscellaneous Cast-in-place Applications) Concrete" with a minimum 28-day compressive strength of 3000 psi (20 MPa), 3-inch (75-mm) slump, and 1-inch (25-mm)

maximum aggregate size or dry, packaged, normal-weight concrete mix complying with ASTM C 387 mixed with potable water according to manufacturer's written instructions.

3. Nonshrink Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107 and specifically recommended by manufacturer for exterior applications.

E. Grounding Materials

1. Grounding Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.
   a. Material above Finished Grade: Copper **OR** Aluminum, **as directed**.
   b. Material on or below Finished Grade: Copper.
   c. Bonding Jumpers: Braided copper tape, 1 inch (25 mm) wide, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.
2. Grounding Connectors and Grounding Rods: Comply with UL 467.
   a. Connectors for Below-Grade Use: Exothermic-welded type.
   b. Grounding Rods: Copper-clad steel.
      1) Size: 5/8 by 96 inches (16 by 2440 mm).

F. Decorative Metallic-Coated Steel Tubular Picket Fences

1. Decorative Metallic-Coated Steel Tubular Picket Fences: Comply with ASTM F 2408, for residential **OR** light industrial (commercial) **OR** industrial, **as directed**, application (class) unless otherwise indicated.
2. Metallic-Coated Steel Sheet: Galvanized-steel sheet or aluminum-zinc alloy-coated steel sheet.
3. Interior surface of tubes formed from uncoated steel sheet shall be hot-dip zinc coated same as exterior or coated with zinc-rich thermosetting coating to comply with ASTM F 2408.
4. Posts:
   a. End and Corner Posts: Square tubes 2-1/2 by 2-1/2 inches (64 by 64 mm) **OR** 3 by 3 inches (76 by 76 mm), **as directed**, formed from 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or formed from 0.105-inch (2.66-mm) nominal-thickness steel sheet and hot-dip galvanized after fabrication.
   b. Swing Gate Posts:
      1) Square tubes 3 by 3 inches (76 by 76 mm) formed from 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or formed from 0.105-inch (2.66-mm) nominal-thickness steel sheet and hot-dip galvanized after fabrication.
      OR
      Square steel tubing 3 by 3 inches (76 by 76 mm) **OR** 4 by 4 inches (102 by 102 mm), **as directed**, with 3/16-inch (4.76-mm) wall thickness, hot-dip galvanized.
   c. Horizontal-Slide Gate Post, Openings up to 12 Feet (3.7 m): Square steel tubing 3 by 3 inches (76 by 76 mm) **OR** 4 by 4 inches (102 by 102 mm), **as directed**, with 3/16-inch (4.76-mm) wall thickness, hot-dip galvanized.
   d. Horizontal-Slide Gate Post, Openings Wider Than 12 Feet (3.7 m): Square steel tubing 4 by 4 inches (102 by 102 mm) with 3/16-inch (4.76-mm) wall thickness, hot-dip galvanized.
   e. Guide Posts for Class 1 Horizontal-Slide Gates:
      1) Square tubes 3 by 3 inches (76 by 76 mm) formed from 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or formed from 0.105-inch (2.66-mm) nominal-thickness steel sheet and hot-dip galvanized after fabrication; installed adjacent to gate post to permit gate to slide in space between.
      OR
      Square steel tubing 3 by 3 inches (76 by 76 mm) **OR** 4 by 4 inches (102 by 102 mm), **as directed**, with 3/16-inch (4.76-mm) wall thickness, hot-dip galvanized; installed adjacent to gate post to permit gate to slide in space between.
5. Post Caps: Formed from steel sheet and hot-dip galvanized after forming **OR** UV-resistant plastic **OR** Aluminum castings **OR** Aluminum castings with round ball finials, **as directed**.
6. Rails: Square tubes **OR** Double-wall channels, **as directed**.
   a. Size: 1-1/2 by 1-1/2 inches (38 by 38 mm) **OR** 1-3/4 by 1-3/4 inches (45 by 45 mm), **as directed**.

b. Metal and Thickness: 0.079-inch (2.01-mm) nominal-thickness, metallic-coated steel sheet or 0.075-inch (1.90-mm) nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.

7. Pickets: Square tubes.
   a. Terminate tops of pickets at top rail for flush top appearance **OR** Extend pickets beyond top rail as indicated and terminate with UV-resistant plastic caps **OR** Extend pickets beyond top rail as indicated and terminate with galvanized-steel caps **OR** Extend pickets beyond top rail as indicated and press flat and trim to produce spear point shape, **as directed**.
   b. Picket Spacing: 6 inches (152.4 mm) **OR** 4 inches (101.6 mm) **OR** 1-3/4 inches (44 mm), **as directed**, clear, maximum.
8. Fasteners: Manufacturer's standard concealed fastening system.
9. Fasteners: Manufacturer's standard tamperproof, **as directed**, corrosion-resistant, color-coated fasteners matching fence components, with resilient polymer washers, **as directed**.
10. Galvanizing: For components indicated to be galvanized and for which galvanized coating is not specified in ASTM F 2408, hot-dip galvanize to comply with ASTM A 123/A 123M. For hardware items, hot-dip galvanize to comply with ASTM A 153/A 153M.
11. Finish: Organic coating complying with requirements in ASTM F 2408 **OR** Powder coating, **as directed**.

G. Decorative Metallic-Coated Steel Wire Fences
1. Metallic-Coated Steel Wire: Welded-wire fence fabric, hot-dip galvanized after fabrication. Weight of zinc coating shall be not less than 1.0 oz./sq. ft. (305 g/sq. m).
   a. Spacing of Vertical Wires: 1-3/4 inches (44 mm) **OR** 2 inches (51 mm) **OR** 3-1/2 inches (89 mm) **OR** 4 inches (102 mm) **OR** As indicated, **as directed**.
   b. Vertical Wire Size: 0.187 inch (4.76 mm) **OR** 0.192 inch (4.88 mm) **OR** 0.225 inch (5.72 mm) **OR** 0.25 inch (6.35 mm) **OR** 0.262 inch (6.67 mm), **as directed**.
   c. Spacing of Horizontal Wires: 1-3/4 inches (44 mm) **OR** 2 inches (51 mm) **OR** 4 inches (102 mm) **OR** 8 inches (203 mm) **OR** As indicated, **as directed**.
   d. Horizontal Wire Size: 0.187 inch (4.76 mm) **OR** 0.192 inch (4.88 mm) **OR** 0.225 inch (5.72 mm) **OR** 0.25 inch (6.35 mm) **OR** 0.312 inch (7.94 mm), **as directed**.
2. Metallic-Coated Steel Sheet: Galvanized-steel sheet or aluminum-zinc alloy-coated steel sheet.
3. Interior surface of tubes formed from uncoated steel sheet shall be hot-dip zinc coated same as exterior or coated with zinc-rich thermosetting coating to comply with ASTM F 2408.
4. Posts:
   a. Line Posts: Square tubes 2 by 2 inches (50 by 50 mm) **OR** 2-1/2 by 2-1/2 inches (64 by 64 mm) **OR** 3 by 3 inches (76 by 76 mm), **as directed**, formed from 0.064-inch (1.63-mm) **OR** 0.079-inch (2.01-mm) **OR** 0.108-inch (2.74-mm), **as directed**, nominal-thickness, metallic-coated steel sheet or formed from 0.060-inch (1.52-mm) **OR** 0.075-inch (1.90-mm) **OR** 0.105-inch (2.66-mm), **as directed**, nominal-thickness steel sheet and hot-dip galvanized after fabrication.
   b. End and Corner Posts: Square tubes 2-1/2 by 2-1/2 inches (64 by 64 mm) **OR** 3 by 3 inches (76 by 76 mm), **as directed**, formed from 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or formed from 0.105-inch (2.66-mm) nominal-thickness steel sheet and hot-dip galvanized after fabrication.
   c. Swing Gate Posts:
      1) Square tubes 3 by 3 inches (76 by 76 mm) formed from 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or formed from 0.105-inch (2.66-mm) nominal-thickness steel sheet and hot-dip galvanized after fabrication.
      OR
      Square steel tubing 3 by 3 inches (76 by 76 mm) **OR** 4 by 4 inches (102 by 102 mm), **as directed**, with 3/16-inch (4.76-mm) wall thickness, hot-dip galvanized.
   d. Horizontal-Slide Gate Post, Openings up to 12 Feet (3.7 m): Square steel tubing 3 by 3 inches (76 by 76 mm) **OR** 4 by 4 inches (102 by 102 mm), **as directed**, with 3/16-inch (4.76-mm) wall thickness, hot-dip galvanized.

e. Horizontal-Slide Gate Post, Openings Wider Than 12 Feet (3.7 m): Square steel tubing 4 by 4 inches (102 by 102 mm) with 3/16-inch (4.76-mm) wall thickness, hot-dip galvanized.
f. Guide Posts for Class 1 Horizontal-Slide Gates:
1) Square tubes 3 by 3 inches (76 by 76 mm) formed from 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or formed from 0.105-inch (2.66-mm) nominal-thickness steel sheet and hot-dip galvanized after fabrication; installed adjacent to gate post to permit gate to slide in space between.
OR
Square steel tubing 3 by 3 inches (76 by 76 mm) **OR** 4 by 4 inches (102 by 102 mm), **as directed**, with 3/16-inch (4.76-mm) wall thickness, hot-dip galvanized; installed adjacent to gate post to permit gate to slide in space between.

5. Post Caps: Formed from steel sheet and hot-dip galvanized after forming **OR** UV-resistant plastic **OR** Aluminum castings **OR** Aluminum castings with round ball finials, **as directed**.
6. Rails: Square tubes.
a. Size: 1-3/16 by 1-1/2 inches (30 by 38 mm) **OR** 1-3/8 by 1-1/2 inches (35 by 38 mm) **OR** 1-1/2 by 1-1/2 inches (38 by 38 mm), **as directed**.
b. Metal and Thickness: 0.064-inch (1.63-mm) **OR** 0.079-inch (2.01-mm), **as directed**, nominal-thickness, metallic-coated steel sheet or 0.060-inch (1.52-mm) **OR** 0.075-inch (1.90-mm), **as directed**, nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.
7. Fasteners: Manufacturer's standard tamperproof, **as directed**, corrosion-resistant, color-coated fasteners matching fence components with resilient polymer washers or clips, **as directed**.
8. Galvanizing: For components indicated to be galvanized and for which galvanized coating is not specified, hot-dip galvanize to comply with ASTM A 123/A 123M. For hardware items, hot-dip galvanize to comply with ASTM A 153/A 153M.
9. Finish: Organic coating complying with requirements in ASTM F 2408 **OR** Powder coating, **as directed**.

H. Decorative Metallic-Coated Steel Security Fences
1. Posts: 1-3/4-by-4-inch (45-by-102-mm) double-thickness, I-shaped sections.
a. Metal and Thickness: 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or 0.105-inch (2.66-mm) nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.
2. Post Caps: Aluminum castings.
3. Rails: 2-by-2-1/2-inch (50-by-64-mm) pentagon-shaped box channel designed to shed water and to enclose wire rope reinforcement.
a. Metal and Thickness: 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or 0.105-inch (2.66-mm) nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.
b. Wire Rope Reinforcement: 3/4-inch (19-mm) zinc-coated steel wire rope.
4. Pickets: 3/4-by-2-3/4-inch (19-by-70-mm) M-shaped pales.
a. Metal and Thickness: 0.079-inch (2.01-mm) nominal-thickness, metallic-coated steel sheet or 0.075-inch (1.90-mm) nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.
b. Extend pickets beyond top rail as indicated and terminate with rounded edge **OR** cut and split to form three points, **as directed**.
c. Picket Spacing: 6 inches (152.4 mm) o.c.
5. Fasteners: Stainless-steel carriage bolts with tamperproof nuts.
6. Galvanizing: For components indicated to be galvanized, hot-dip galvanize to comply with ASTM A 123/A 123M unless otherwise indicated. For hardware items, hot-dip galvanize to comply with ASTM A 153/A 153M.
7. Finish: Powder coating.

I. Decorative Steel Fences
1. Decorative Steel Fences: Fences made from steel tubing bars, **as directed**, and shapes, hot-dip galvanized, **as directed**.

2. Posts: Square steel tubing.
   a. Line Posts: 2 by 2 inches (50 by 50 mm) **OR** 2-1/2 by 2-1/2 inches (64 by 64 mm) **OR** 3 by 3 inches (76 by 76 mm), **as directed**, with 1/8-inch (3.2-mm) **OR** 3/16-inch (4.76-mm), **as directed**, wall thickness.
   b. End and Corner Posts: 2-1/2 by 2-1/2 inches (64 by 64 mm) **OR** 3 by 3 inches (76 by 76 mm) **OR** 4 by 4 inches (102 by 102 mm), **as directed**, with 1/8-inch (3.2-mm) **OR** 3/16-inch (4.76-mm), **as directed**, wall thickness.
   c. Swing Gate Posts: 3 by 3 inches (76 by 76 mm) **OR** 4 by 4 inches (102 by 102 mm), **as directed**, with 3/16-inch (4.76-mm) wall thickness.
   d. Horizontal-Slide Gate Post, Openings up to 12 Feet (3.7 m): 3 by 3 inches (76 by 76 mm) **OR** 4 by 4 inches (102 by 102 mm), **as directed**, with 3/16-inch (4.76-mm) wall thickness.
   e. Horizontal-Slide Gate Post, Openings Wider Than 12 Feet (3.7 m): 4 by 4 inches (102 by 102 mm) with 3/16-inch (4.76-mm) wall thickness.
   f. Guide Posts for Class 1 Horizontal-Slide Gates: 3 by 3 inches (76 by 76 mm) **OR** 4 by 4 inches (102 by 102 mm), **as directed**, with 3/16-inch (4.76-mm) wall thickness; installed adjacent to gate post to permit gate to slide in space between.
3. Post Caps: Formed from steel sheet **OR** Formed from steel sheet and hot-dip galvanized after forming **OR** Aluminum castings **OR** Aluminum castings with round ball finials, **as directed**.
4. Rails:
   a. Steel Tube Rails: Square steel tubing 2 by 2 inches (50 by 50 mm) **OR** 2-1/2 by 2-1/2 inches (64 by 64 mm), **as directed**, with 1/8-inch (3.2-mm) wall thickness.
   b. Steel Channel Rails: Steel channels 2 by 1 inch (50 by 25 mm) **OR** 1-1/2 by 3/4 inch (38 by 19 mm) **OR** 1-1/2 by 1/2 inch (38 by 13 mm), **as directed**.
5. Pickets: 1/2-inch- (13-mm-) square steel bars **OR** 3/4-inch- (19-mm-) square steel bars **OR** Decorative steel bars of pattern and size indicated **OR** 5/8 inch (16 mm) square by 0.065-inch (1.65-mm) steel tubes **OR** 5/8 inch (16 mm) square by 0.083-inch (2.11-mm) steel tubes **OR** 3/4 inch (19 mm) square by 0.065-inch (1.65-mm) steel tubes **OR** 3/4 inch (19 mm) square by 0.083-inch (2.11-mm) steel tubes **OR** 1 inch (25 mm) square by 0.065-inch (1.65-mm) steel tubes **OR** 1 inch (25 mm) square by 0.083-inch (2.11-mm) steel tubes, **as directed**.
   a. Terminate tops of pickets at top rail for flush top appearance **OR** Extend pickets beyond top rail as indicated and mill ends to pyramid shaped points **OR** Extend pickets beyond top rail as indicated and press flat and trim to produce spear point shape **OR** Extend pickets beyond top rail as indicated and cap with metal spear point finial **OR** Extend pickets beyond top rail as indicated and cap with metal tripoint finial, **as directed**.
   b. Picket Spacing: 6 inches (152.4 mm) **OR** 4 inches (101.6 mm) **OR** 1-3/4 inches (44 mm), **as directed**, clear, maximum.
   c. Treillage: Provide iron castings of pattern indicated between each pair of pickets.
6. Infill: Forge-welded steel bar grating.
   a. Perimeter Bars: Steel flat bars 1 by 1/8 inch (25 by 3.2 mm).
   b. Vertical Main Bars: Steel flat bars 1 by 1/8 inch (25 by 3.2 mm) **OR** 1-3/16 by 5/32 inch (30 by 4 mm), **as directed**.
   c. Vertical Main Bar Spacing: 1-21/32 inches (42 mm) **OR** 1-7/8 inches (48 mm) **OR** 2-7/16 inches (62 mm), **as directed**, o.c.
   d. Horizontal Cross Rods: 3/16-inch- (4.8-mm-) **OR** 1/4-inch- (6.4-mm-), **as directed,** diameter, steel rods.
   e. Horizontal Cross Rod Spacing: 1-3/4 inches (45 mm) **OR** 2-19/32 inches (66 mm) **OR** 5-3/16 inches (132 mm), **as directed**, o.c.
7. Infill: Custom design as indicated on Drawings.
   a. Bars: 1/2-inch- (12.7 -mm-) square steel bars **OR** 3/4-inch- (19-mm-) square steel bars **OR** 1/2-inch- (12.7 -mm-) diameter, round steel bars **OR** 3/4-inch- (19-mm-) diameter, round steel bars **OR** 1-by-1/8-inch (25-by-3.2-mm) steel flat bars **OR** 1-by-1/4-inch (25-by-6.4-mm) steel flat bars **OR** 1-by-1/2-inch (25-by-12.7 -mm) steel flat bars, **as directed**, unless otherwise indicated.

b. Square Tubes: Square steel tubing 2 by 2 inches (50 by 50 mm) **OR** 2-1/2 by 2-1/2 inches (64 by 64 mm), **as directed**, with 1/8-inch (3.2-mm) wall thickness unless otherwise indicated.
c. Round Tubes: 1-inch- (25-mm-) **OR** 1-1/2-inch- (38-mm-) **OR** 2-inch- (50-mm-) **OR** 2-1/2-inch- (64-mm-), **as directed**, diameter, round steel tubing with 1/8-inch (3.2-mm) wall thickness unless otherwise indicated.
d. Steel Plate: 1/8 inch (3.2 mm) **OR** 3/16 inch (4.8 mm) **OR** 1/4 inch (6.4 mm), **as directed**, thick unless otherwise indicated.
e. Perforated Metal Sheet: Uncoated steel sheet, perforated as indicated, 0.060-inch (1.52-mm) **OR** 0.075-inch (1.90-mm) **OR** 0.105-inch (2.66-mm), **as directed**, nominal thickness.

8. Fasteners: Stainless-steel carriage bolts and tamperproof, **as directed**, nuts.
9. Fabrication:
   a. Assemble fences into sections by welding pickets to rails.
      1) Fabricate sections with clips welded to rails for fastening to posts in field.
      2) Drill posts and clips for fasteners before finishing to maximum extent possible.
   b. Fabricate bar grating infill into sections of size indicated.
      1) Fabricate rails with clips welded to rails for fastening to posts in field.
      2) Drill posts**,** clips, **as directed**, and bar grating for fasteners before finishing to maximum extent possible.
10. Finish exposed welds to comply with NOMMA Guideline 1, Finish #2 - completely sanded joint, some undercutting and pinholes okay **OR** Finish #3 - partially dressed weld with splatter removed **OR** Finish #4 - good-quality, uniform undressed weld with minimal splatter, **as directed**.
11. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A 123/A 123M. For hardware items, hot-dip galvanize to comply with ASTM A 153/A 153M.
    a. Hot-dip galvanize posts and rails, **as directed**.
    b. Hot-dip galvanize rail and picket assemblies after fabrication.
    c. Hot-dip galvanize bar grating infill after fabrication.
    d. Hot-dip galvanize custom-design rail and infill assemblies after fabrication.
12. Finish for Bar Grating Infill: Powder coating.
13. Finish for Steel Items Other than Bar Grating Infill: Primed **OR** Shop painted **OR** High-performance coating, **as directed**.
14. Finish for Metallic-Coated Steel Items Other than Bar Grating Infill: High-performance coating **OR** Galvanized finish, **as directed**.

J. Decorative Aluminum Fences
1. Decorative Aluminum Fences: Fences made from aluminum extrusions.
2. Posts: Square extruded tubes.
   a. Line Posts: 2 by 2 inches (50 by 50 mm) **OR** 2-1/2 by 2-1/2 inches (64 by 64 mm) **OR** 3 by 3 inches (76 by 76 mm), **as directed**, with 0.062-inch (1.57-mm) **OR** 0.080-inch (2.03-mm) **OR** 0.093-inch (2.36-mm) **OR** 0.100-inch (2.54-mm) **OR** 0.125-inch (3.18-mm), **as directed**, wall thickness.
   b. End and Corner Posts: 2 by 2 inches (50 by 50 mm) **OR** 2-1/2 by 2-1/2 inches (64 by 64 mm) **OR** 3 by 3 inches (76 by 76 mm), **as directed**, with 0.062-inch (1.57-mm) **OR** 0.080-inch (2.03-mm) **OR** 0.093-inch (2.36-mm) **OR** 0.100-inch (2.54-mm) **OR** 0.125-inch (3.18-mm), **as directed**, wall thickness.
   c. Swing Gate Posts: 2-1/2 by 2-1/2 inches (64 by 64 mm) **OR** 3 by 3 inches (76 by 76 mm) **OR** 4 by 4 inches (102 by 102 mm), **as directed**, with 0.125-inch (3.18-mm) **OR** 0.250-inch (6.35-mm), **as directed**, wall thickness.
   d. Horizontal-Slide Gate Post, Openings up to 12 Feet (3.7 m): 2-1/2 by 2-1/2 inches (64 by 64 mm) **OR** 3 by 3 inches (76 by 76 mm) **OR** 4 by 4 inches (102 by 102 mm), **as directed**, with 0.125-inch (3.18-mm) **OR** 0.250-inch (6.35-mm), **as directed**, wall thickness.
   e. Horizontal-Slide Gate Post, Openings Wider Than 12 Feet (3.7 m): 3 by 3 inches (76 by 76 mm) **OR** 4 by 4 inches (102 by 102 mm) **OR** 6 by 6 inches (152 by 152 mm), **as directed**, with 0.125-inch (3.18-mm) **OR** 0.250-inch (6.35-mm), **as directed**, wall thickness.

f. Guide Posts for Class 1 Horizontal-Slide Gates: 2 by 2 inches (50 by 50 mm) **OR** 2-1/2 by 2-1/2 inches (64 by 64 mm) **OR** 3 by 3 inches (76 by 76 mm), **as directed**, with 0.062-inch (1.57-mm) **OR** 0.093-inch (2.36-mm) **OR** 0.125-inch (3.18-mm), **as directed**, wall thickness; installed adjacent to gate post to permit gate to slide in space between.

3. Post Caps: Aluminum castings that cover entire top of posts **OR** project at least 1/4 inch (6 mm) beyond posts, **as directed**, with round ball finial, **as directed**.
4. Rails: Extruded-aluminum channels, 1-1/2 by 1-1/2 inches (38 by 38 mm), with 0.100-inch- (2.54-mm-) thick sidewalls and 0.070-inch- (1.78-mm-) thick top **OR** 1 by 1-1/2 inches (25 by 38 mm), with 0.082-inch- (2.08-mm-) thick sidewalls and 0.055-inch- (1.40-mm-) thick top **OR** 1-1/4 by 1-1/4 inches (32 by 32 mm), with 0.078-inch- (1.98-mm-) thick sidewalls and 0.062-inch- (1.57-mm-) thick top **OR** 1 by 1 inch (25 by 25 mm), with 0.080-inch- (2.03-mm-) thick sidewalls and 0.055-inch- (1.40-mm-) thick top **OR** 1 by 1 inch (25 by 25 mm), with 0.078-inch- (1.98-mm-) thick sidewalls and 0.062-inch- (1.57-mm-) thick top, **as directed**.
5. Pickets: Extruded-aluminum tubes, 1 inch (25 mm) square, with 0.062-inch (1.57-mm) wall thickness **OR** 1 inch (25 mm) square, with 0.060-inch (1.52-mm) wall thickness **OR** 3/4 inch (19 mm) square, with 0.050-inch (1.27-mm) wall thickness **OR** 1 by 5/8 inch (25 by 16 mm), with 0.050-inch (1.27-mm) wall thickness **OR** 5/8 inch (16 mm) square, with 0.050-inch (1.27-mm) wall thickness, **as directed**.
   a. Terminate tops of pickets at top rail for flush top appearance **OR** Extend pickets beyond top rail as indicated and terminate with UV-resistant plastic caps **OR** Extend pickets beyond top rail as indicated and terminate with cast-aluminum caps **OR** Extend pickets beyond top rail as indicated and press flat and trim to produce spear point shape **OR** Extend pickets beyond top rail as indicated and terminate with cast-aluminum spear point finial **OR** Extend pickets beyond top rail as indicated and terminate with cast-aluminum tripoint finial, **as directed**.
   b. Picket Spacing: 6 inches (152.4 mm) **OR** 4 inches (101.6 mm) **OR** 1-3/4 inches (44 mm), **as directed**, clear, maximum.
6. Fasteners:
   a. Manufacturer's standard concealed fastening system.
      OR
      Manufacturer's standard tamperproof, **as directed**, corrosion-resistant, color-coated fasteners matching fence components with resilient polymer washers, **as directed**.
7. Fabrication: Assemble fences into sections by welding **OR** fastening, **as directed**, pickets to rails.
   a. Fabricate sections with clips welded to rails for fastening to posts in field.
   b. Drill clips for fasteners before finishing.
8. Finish exposed welds to comply with NOMMA Guideline 1, Finish #2 - completely sanded joint, some undercutting and pinholes okay **OR** Finish #3 - partially dressed weld with splatter removed **OR** Finish #4 - good-quality, uniform undressed weld with minimal splatter, **as directed**.
9. Finish: Baked enamel or powder coating.

K. Swing Gates
1. Gate Configuration: Single leaf **OR** Double leaf, **unless directed otherwise**.
2. Gate Frame Height: 72 inches (1830 mm), **unless directed otherwise**.
3. Gate Opening Width: 36 inches (914 mm), **unless directed otherwise**.
4. Galvanized-Steel Frames and Bracing: Fabricate members from square tubes 1-1/2 by 1-1/2 inches (38 by 38 mm) **OR** 1-3/4 by 1-3/4 inches (45 by 45 mm) **OR** 2 by 2 inches (50 by 50 mm) **OR** 2-1/2 by 2-1/2 inches (64 by 64 mm), **as directed**, formed from 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or formed from 0.105-inch (2.66-mm) nominal-thickness steel sheet and hot-dip galvanized after fabrication.
5. Steel Frames and Bracing: Fabricate members from square steel tubing 1-1/2 by 1-1/2 inches (38 by 38 mm) **OR** 2 by 2 inches (50 by 50 mm) **OR** 2-1/2 by 2-1/2 inches (64 by 64 mm), **as directed**, with 1/8-inch (3.2-mm) wall thickness. Hot-dip galvanize frames after fabrication, **as directed**.

6. Aluminum Frames and Bracing: Fabricate members from square extruded-aluminum tubes 1-1/2 by 1-1/2 inches (38 by 38 mm) **OR** 2 by 2 inches (50 by 50 mm) **OR** 2-1/2 by 2-1/2 inches (64 by 64 mm), **as directed**, with 0.100-inch (2.54-mm) **OR** 0.125-inch (3.18-mm) **OR** 0.140-inch (3.56-mm) **OR** 0.154-inch (3.91-mm), **as directed**, wall thickness.
7. Frame Corner Construction: Welded or assembled with corner fittings and 5/16-inch- (7.9-mm-) diameter, adjustable truss rods for panels 5 feet (1.52 m) wide or wider.
8. Additional Rails: Provide as indicated, complying with requirements for fence rails.
9. Infill: Comply with requirements for adjacent fence.
10. Picket Size, Configuration, and Spacing: Comply with requirements for adjacent fence.
    a. Treillage: Provide iron castings of pattern indicated between each pair of pickets. Finish as specified for adjacent fence **OR** gates, **as directed**.
11. Hardware: Latches permitting operation from both sides of gate, hinges, and keepers for each gate leaf more than 5 feet (1.52 m) wide. Provide center gate stops and cane bolts for pairs of gates. Fabricate latches with integral eye openings for padlocking; padlock accessible from both sides of gate, **as directed**.
12. Spring Hinges: BHMA A156.17, Grade 1, suitable for exterior use.
    a. Function: 320 - Gate spring pivot hinge. Adjustable tension **OR** 321 - Gate spring pivot hinge. Fixed tension, **as directed**.
    b. Material: Malleable iron.
13. Hinges: BHMA A156.1, Grade 1, suitable for exterior use.
    a. Function: 39 - Full surface, triple weight, antifriction bearing.
    b. Material: Wrought steel, forged steel, cast steel, or malleable iron.
14. Rim Locks: BHMA A156.5, Grade 1, suitable for exterior use.
    a. Function: 621 - Latchbolt by key from outside and by turn from inside. Latchbolt is held retracted by device from inside **OR** 622 - Deadbolt by key from outside and by turn from inside **OR** 629 - Deadlocking latchbolt by key from outside and by turn from inside **OR** 626 - Interlocking deadbolt operated by key from either side **OR** 627 - Interlocking deadbolt operated by key from outside and by turn from inside, **as directed**.
    b. Material: Cast, forged, or extruded brass or bronze.
    c. Mounting Plate: Configuration necessary for mounting locks. Fabricate from 1/8-inch- (3.2-mm-) thick, steel **OR** aluminum, **as directed**, plate.
15. Mortise Locks: BHMA A156.13, Grade 1, suitable for exterior use.
    a. Function: F06 - Holdback lock **OR** F07 - Storeroom or closet lock **OR** F09 - Apartment, exit, or public toilet lock **OR** F16 - Double-cylinder dead lock **OR** F17 - Dead lock, **as directed**.
    b. Material: Brass or bronze.
    c. Levers: Cast, forged, or extruded brass or bronze.
    d. Mounting Box: Configuration necessary to enclose locks. Fabricate from 1/8-inch- (3.2-mm-) thick, steel **OR** aluminum, **as directed**, plate.
16. Electric Strikes: BHMA A156.31, Grade 1, of configuration required for use with lock specified, fail safe **OR** fail secure, **as directed**, and suitable for exterior use.
    a. Mounting Plate: Configuration necessary for mounting electric strikes. Fabricate from 1/8-inch- (3.2-mm-) thick, steel **OR** aluminum, **as directed**, plate.
    b. Mounting: Mortise into post.
17. Exit Hardware: BHMA A156.3, Grade 1, Type 1 (rim exit device), with push pad actuating bar, suitable for exterior use.
    a. Function: 01 - Exit only, no trim or blank escutcheon **OR** 04 - Entrance by trim when latch bolt is released by key or set in a retracted position by key **OR** 08 - Entrance by lever. Key locks or unlocks lever **OR** 09 - Entrance by lever only when released by key. Key removable only when locked, **as directed**.
    b. Mounting Channel: Bent-plate channel formed from 1/8-inch- (3.2-mm-) thick, steel **OR** aluminum, **as directed**, plate. Channel spans gate frame. Exit device is mounted on channel web, recessed between flanges, with flanges extending 1/8 inch (3.2 mm) beyond push pad surface.
18. Cane Bolts: Provide for inactive leaf of pairs of gates. Fabricated from 1/2-inch- (12.7 -mm-) **OR** 3/4-inch- (19-mm-), **as directed**, diameter, round steel bars, hot-dip galvanized after fabrication.

Finish to match gates. Provide galvanized-steel pipe strikes to receive cane bolts in closed position **OR** both open and closed positions, **as directed**.

19. Finish exposed welds to comply with NOMMA Guideline 1, Finish #2 - completely sanded joint, some undercutting and pinholes okay **OR** Finish #3 - partially dressed weld with splatter removed **OR** Finish #4 - good-quality, uniform undressed weld with minimal splatter, **as directed**.
20. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A 123/A 123M unless otherwise indicated. For hardware items, hot-dip galvanize to comply with ASTM A 153/A 153M.
21. Metallic-Coated Steel Finish: High-performance coating **OR** Galvanized finish, **as directed**.
22. Steel Finish: Primed **OR** Shop painted **OR** High-performance coating, **as directed**.
23. Aluminum Finish: Baked enamel or powder coating.

L. Horizontal-Slide Gates

1. Gate Configuration: Single leaf **OR** Double leaf **OR** As indicated, **as directed**.
   a. Type:
      1) Overhead slide.
         OR
         Cantilever slide, with external **OR** internal, **as directed**, roller assemblies.
2. Gate Frame Height: 72 inches (1830 mm), **unless directed otherwise**.
3. Gate Opening Width: 36 inches (914 mm), **unless directed otherwise**.
4. Galvanized-Steel Frames and Bracing: Fabricate members from square tubing.
   a. Frame Members: Square tubes 1-1/2 by 1-1/2 inches (38 by 38 mm) **OR** 1-3/4 by 1-3/4 inches (45 by 45 mm) **OR** 2 by 2 inches (50 by 50 mm) **OR** 2-1/2 by 2-1/2 inches (64 by 64 mm), **as directed**, formed from 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or formed from 0.105-inch (2.66-mm) nominal-thickness steel sheet and hot-dip galvanized after fabrication.
   b. Bracing Members: Square tubes 1-1/2 by 1-1/2 inches (38 by 38 mm) **OR** 1-3/4 by 1-3/4 inches (45 by 45 mm) **OR** 2 by 2 inches (50 by 50 mm) **OR** 2-1/2 by 2-1/2 inches (64 by 64 mm), **as directed**, formed from 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or formed from 0.105-inch (2.66-mm) nominal-thickness steel sheet and hot-dip galvanized after fabrication.
5. Steel Frames and Bracing: Fabricate members from square tubing. Hot-dip galvanize frames after fabrication, **as directed**.
   a. Frame Members: Steel tubing 1-1/2 by 1-1/2 inches (38 by 38 mm) **OR** 2 by 2 inches (50 by 50 mm) **OR** 2-1/2 by 2-1/2 inches (64 by 64 mm), **as directed**, with 1/8-inch (3.2-mm) wall thickness.
   b. Bracing Members: Steel tubing 1-1/2 by 1-1/2 inches (38 by 38 mm) **OR** 2 by 2 inches (50 by 50 mm) **OR** 2-1/2 by 2-1/2 inches (64 by 64 mm), **as directed**, with 1/8-inch (3.2-mm) wall thickness.
6. Aluminum Frames and Bracing: Fabricate members from square tubing.
   a. Frame Members: Extruded-aluminum tubes 1-1/2 by 1-1/2 inches (38 by 38 mm) **OR** 2 by 2 inches (50 by 50 mm) **OR** 2-1/2 by 2-1/2 inches (64 by 64 mm), **as directed**, with 0.100-inch (2.54-mm) **OR** 0.125-inch (3.18-mm) **OR** 0.140-inch (3.56-mm) **OR** 0.154-inch (3.91-mm), **as directed**, wall thickness.
   b. Bracing Members: Extruded-aluminum tubes 1-1/2 by 1-1/2 inches (38 by 38 mm) **OR** 2 by 2 inches (50 by 50 mm) **OR** 2-1/2 by 2-1/2 inches (64 by 64 mm)**, as directed,** with 0.100-inch (2.54-mm) **OR** 0.125-inch (3.18-mm) **OR** 0.140-inch (3.56-mm) **OR** 0.154-inch (3.91-mm), **as directed**, wall thickness.
7. Frame Corner Construction:
   a. Welded frame with panels assembled with bolted or riveted corner fittings and 5/16-inch-(7.9-mm-) diameter, adjustable truss rods for panels 5 feet (1.52 m) wide or wider.
   b. Overhead Slide Gates: Welded or assembled with corner fittings including 5/16-inch- (7.9-mm-) diameter, adjustable truss rods for panels 5 feet (1.52 m) wide or wider.
8. Additional Rails: Provide as indicated, complying with requirements for fence rails.
9. Infill: Comply with requirements for adjacent fence.

10. Picket Size, Configuration, and Spacing: Comply with requirements for adjacent fence.
    a. Treillage: Provide iron castings of pattern indicated between each pair of pickets. Finish as specified for adjacent fence **OR** gates, **as directed**.
11. Overhead Track Assembly: Manufacturer's standard track, with overhead framing supports, bracing, and accessories, engineered to support size, weight, width, operation, and design of gate and roller assemblies.
12. Hardware: Latches permitting operation from both sides of gate, locking devices, hangers, roller assemblies, and stops fabricated from galvanized steel **OR** galvanized malleable iron **OR** mill-finished, Grade 319 aluminum-alloy casting with stainless-steel fasteners, **as directed**. Fabricate latches with integral eye openings for padlocking; padlock accessible from both sides of gate, **as directed**.
13. Finish exposed welds to comply with NOMMA Guideline 1, Finish #2 - completely sanded joint, some undercutting and pinholes okay **OR** Finish #3 - partially dressed weld with splatter removed **OR** Finish #4 - good-quality, uniform undressed weld with minimal splatter, **as directed**.
14. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A 123/A 123M unless otherwise indicated. For hardware items, hot-dip galvanize to comply with ASTM A 153/A 153M.
15. Metallic-Coated Steel Finish: High-performance coating **OR** Galvanized finish, **as directed**.
16. Steel Finish: Primed **OR** Shop painted **OR** High-performance coating, **as directed**.
17. Aluminum Finish: Baked enamel or powder coating.

M. Gate Operators
1. General: Provide factory-assembled automatic operating system designed for gate size, type, weight, and operation frequency. Provide operation control system with characteristics suitable for Project conditions, with remote-control stations, safety devices, and weatherproof enclosures; coordinate electrical requirements with building electrical system.
    a. Provide operator designed so motor may be removed without disturbing limit-switch adjustment and without affecting auxiliary emergency operator.
    b. Provide operator with UL approval **OR** UL-approved components, **as directed**.
    c. Provide electronic components with built-in troubleshooting diagnostic feature.
    d. Provide unit designed and wired for both right-hand/left-hand opening, permitting universal installation.
    e. Provide controllers, electrical devices, and wiring that comply with requirements specified in Division 22.
2. Motors: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 11 Section "Common Motor Requirements For Equipment".
    a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
    b. Horsepower: Not less than 1/4 **OR** 1/3 **OR** 1/2 **OR** 3/4, **as directed**.
    c. Enclosure: Open dripproof **OR** Totally enclosed **OR** Manufacturer's standard, **as directed**.
    d. Duty: Continuous duty at ambient temperature of 105 deg F (40 deg C) and at altitude of 3300 feet (1005 m) above sea level.
    e. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.
    f. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.
3. Gate Operators: Gate **OR** Concrete base **OR** Post **OR** In-ground, **as directed**, mounted and as follows:
    a. Hydraulic Swing **OR** Slide, **as directed**, Gate Operators:
        1) Duty: Light **OR** Medium **OR** Heavy, **as directed**, duty, residential **OR** commercial/industrial, **as directed**.
        2) Gate Speed: Minimum 45 feet (13.7 m) **OR** 60 feet (18.2 m), **as directed**, per minute.
        3) Maximum Gate Weight: Not to exceed operator manufacturer's recommendations.
        4) Frequency of Use: 10 cycles per hour **OR** 25 cycles per hour **OR** Continuous duty, **as directed**.

5) Locking: Hydraulic in both directions.
6) Heater: Manufacturer's standard track and roller heater with thermostatic control, as directed.
7) Operating Type: Crank arm **OR** Wheel and rail drive **OR** Roller chain, **as directed,** with manual release, **as directed**.

b. Mechanical Swing **OR** Slide, **as directed**, Gate Operators:
1) Duty: Light **OR** Medium **OR** Heavy, **as directed**, duty, residential **OR** commercial/industrial, **as directed**.
2) Gate Speed: Minimum 45 feet (13.7 m) per minute **OR** 60 feet (18.2 m) per minute **OR** variable speed, **as directed**.
3) Maximum Gate Weight: 600 lb (272 kg) **OR** 800 lb (363 kg), **as directed**.
4) Frequency of Use: 10 cycles per hour **OR** 25 cycles per hour **OR** 60 cycles per hour **OR** Continuous duty, **as directed**.
5) Operating Type: Crank arm **OR** Wheel and rail drive **OR** Roller chain, **as directed**, with manual release, **as directed**.
6) Drive Type:
a) Enclosed worm gear and chain-and-sprocket, **as directed**, reducers, roller-chain drive.
OR
V-belt and worm gear **OR** chain-and-sprocket, **as directed**, reducers, roller-chain drive.

4. Remote Controls: Electric controls separated from gate and motor and drive mechanism, with NEMA ICS 6, Type 1 **OR** NEMA ICS 6, Type 4, **as directed**, enclosure for surface **OR** recessed or flush, **as directed**, concrete base **OR** pedestal, **as directed**, mounting, and with space for additional optional equipment. Provide the following remote-control device(s):
a. Control Station:
1) Keyed, two-position **OR** three-position, **as directed**, switch with open, stop, **as directed**, and close function; located remotely from gate. Provide two keys per station.
OR
Momentary-contact, single-button-operated **OR** three-button-operated, **as directed**, with open, stop, **as directed**, and close function; located remotely from gate. Key switch to lock out open and close buttons, **as directed**.

b. Card Reader: Functions only when authorized card is presented. Programmable, multiple-code **OR** single-code, **as directed**, system, permitting four different access time periods, **as directed,** face-lighted unit fully visible at night, **as directed**.
1) Reader Type: Touch plate **OR** Swipe **OR** Insertion **OR** Proximity, **as directed**.
2) Features: Timed antipassback **OR** Limited-time usage **OR** Capable of monitoring and auditing gate activity, **as directed**.

c. Digital Keypad Entry Unit: Multiple-programmable **OR** Multiple-code, **as directed**, capability of not less than 5 **OR** 500 **OR** 2500, **as directed**, possible individual codes, consisting of 1- to 7 **OR** 4 **OR** 5, **as directed**,-digit codes, and permitting 4 different access time periods, **as directed**.
1) Features: Timed antipassback **OR** Limited-time usage **OR** Capable of monitoring and auditing gate activity, **as directed**.
2) Face-lighted unit with metal-keyed **OR** keyless-membrane, **as directed**, keypad fully visible at night.

d. Radio Control: Digital system consisting of code-compatible universal receiver for each gate, located where indicated, with remote antenna with coaxial cable and mounting brackets designed to operate gates. Provide 1 **OR** 2, **as directed**, programmable transmitter(s) with multiple-code capability permitting validating or voiding of not less than 1000 **OR** 10,000, **as directed**, codes per channel configured for the following functions:
1) Transmitters: Single **OR** Three, **as directed**,-button operated, with open and close, **as directed**, function.

2) Channel Settings: Two **OR** Three **OR** Four, **as directed**, independent channel settings controlling separate receivers for operating more than one gate from each transmitter.

e. Telephone Entry System: Hands-free, voice-communication system for connection to building telephone system with digital-entry code activation of gate operator and auxiliary keypad entry, **as directed**.
1) Residential System: Designed to be wired to same line with telephone.
2) Multiunit System: Designed to be wired to a dedicated telephone line, with capacity to access 20 **OR** 100, **as directed**, telephones, and with electronic directory, **as directed**.

f. Vehicle Loop Detector: System including automatic closing timer with adjustable time delay before closing, timer cutoff switch, **as directed**, and loop detector designed to open and close gate **OR** hold gate open until traffic clears **OR** reverse gate, **as directed**. Provide electronic detector with adjustable detection patterns, adjustable sensitivity and frequency settings, and panel indicator light designed to detect presence or transit of a vehicle over an embedded loop of wire and to emit a signal activating the gate operator. Provide number of loops consisting of multiple strands of wire, number of turns, loop size, and method of placement at location shown on Drawings, as recommended in writing by detection system manufacturer for function indicated.
1) Loop:
a) Wire, in size indicated for field assembly, for pave-over **OR** saw cut with epoxy-grouted, **as directed**, installation.
OR
Loop: Factory preformed in size indicated; style for pave-over **OR** saw cut with epoxy-grouted, **as directed**, installation.

g. Vehicle Presence Detector: System including automatic closing timer with adjustable time delay before closing, timer cutoff switch, **as directed**, and presence detector designed to open and close gate **OR** hold gate open until traffic clears **OR** reverse gate, **as directed**. Provide retroreflective **OR** emitter/receiver, **as directed**, detector with adjustable detection zone pattern and sensitivity, designed to detect the presence or transit of a vehicle in gate pathway when infrared beam in zone pattern is interrupted, and to emit a signal activating the gate operator.

5. Obstruction Detection Devices: Provide each motorized gate with automatic safety sensor(s). Activation of sensor(s) causes operator to immediately function as follows:
a. Action:
1) Reverse gate in both opening and closing cycles and hold until clear of obstruction.
OR
Stop gate in opening cycle and reverse gate in closing cycle and hold until clear of obstruction.

b. Internal Sensor: Built-in torque or current monitor senses gate is obstructed.

c. Sensor Edge: Contact-pressure-sensitive safety edge, profile, and sensitivity designed for type of gate and component indicated, in locations as follows. Connect to control circuit using take-up cable reel **OR** self-coiling cable **OR** gate edge transmitter and operator receiver system, **as directed**.
1) Along entire gate leaf leading edge **OR** Along entire gate leaf trailing edge **OR** Across entire gate leaf bottom edge **OR** Along entire length of gate posts **OR** Along entire length of gate guide posts **OR** Where indicated on Drawings, **as directed**.

d. Photoelectric/Infrared Sensor System: Designed to detect an obstruction in gate's path when infrared beam in the zone pattern is interrupted.

6. Limit Switches: Adjustable switches, interlocked with motor controls and set to automatically stop gate at fully retracted and fully extended positions.

7. Emergency Release Mechanism: Quick-disconnect release of operator drive system of the following type of mechanism, permitting manual operation if operator fails. Design system so control-circuit power is disconnected during manual operation.
a. Type:

1) Integral fail-safe release, allowing gate to be pushed open without mechanical devices, keys, cranks, or special knowledge.
OR
Mechanical device, key, or crank-activated release.

8. Operating Features:
   a. Digital Microprocessor Control: Electronic programmable means for setting, changing, and adjusting control features with capability for monitoring and auditing gate activity, **as directed**. Provide unit that is isolated from voltage spikes and surges.
   b. System Integration: With controlling circuit board capable of accepting any type of input from external devices.
   c. Master/Slave Capability: Control stations designed and wired for gate pair operation.
   d. Automatic Closing Timer: With adjustable time delay before closing and timer cutoff switch, **as directed**.
   e. Open Override Circuit: Designed to override closing commands.
   f. Reversal Time Delay: Designed to protect gate system from shock load on reversal in both directions.
   g. Maximum Run Timer: Designed to prevent damage to gate system by shutting down system if normal time to open gate is exceeded.
   h. Clock Timer: 24-hour **OR** Seven-day, **as directed**, programmable for regular events.
9. Accessories:
   a. Warning Module: Audio **OR** Visual, **as directed**, ADA/ABA-compliant, constant-light **OR** strobe-light, **as directed**, alarm sounding three to five seconds in advance of gate operation and continuing until gate stops moving.
   b. Battery Backup System: Battery-powered drive and access-control system, independent of primary drive system:
      1) Fail Safe: Gate opens and remains open until power is restored.
      2) Fail Secure: Gate cycles on battery power, then fail safe when battery is discharged.
   c. External electric-powered solenoid **OR** magnetic, **as directed**, lock with delay timer allowing time for lock to release before gate operates.
   d. Fire **OR** Postal, **as directed**, box.
   e. Fire strobe **OR** siren, **as directed**, alarm.
   f. Intercom System: as directed by the Owner.
   g. Instructional, Safety, and Warning Labels and Signs: According to UL 325 **OR** Manufacturer's standard for components and features specified **OR** As indicated on Drawings, **as directed**.

N. Aluminum Finishes
1. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 2 mils (0.05 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
   a. Color and Gloss: As selected from manufacturer's full range.

O. Steel Finishes
1. Surface Preparation: Clean surfaces according to SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning **OR** SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning", **as directed**.
   a. After cleaning, apply a conversion coating suited to the organic coating to be applied over it.
2. Powder Coating: Immediately after cleaning, apply 2-coat finish consisting of epoxy primer and TGIC polyester topcoat, with a minimum total dry film thickness of not less than 8 mils (0.20 mm). Comply with coating manufacturer's written instructions.
   a. Color and Gloss: As selected from manufacturer's full range.
3. Primer Application: Apply zinc-rich epoxy primer immediately after cleaning, to provide a minimum dry film thickness of 2 mils (0.05 mm) per applied coat, to surfaces that will be exposed after assembly and installation, and to concealed surfaces.

4. Shop-Painted Finish: Comply with Division 09 Section(s) "Exterior Painting" OR "High-performance Coatings", **as directed**.
5. High-Performance Coating: Apply epoxy intermediate and polyurethane topcoats to prime-coated surfaces. Comply with coating manufacturer's written instructions and with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Apply at spreading rates recommended by coating manufacturer.
   a. Match approved Samples for color, texture, and coverage. Remove and refinish, or recoat work that does not comply with specified requirements.

P. Metallic-Coated Steel Finishes
1. Galvanized Finish: Clean welds, mechanical connections, and abraded areas and repair galvanizing to comply with ASTM A 780.
2. Surface Preparation: Clean surfaces with nonpetroleum solvent so surfaces are free of oil and other contaminants. After cleaning, apply a zinc-phosphate, **as directed**, conversion coating suited to the organic coating to be applied over it. Clean welds, mechanical connections, and abraded areas and repair galvanizing to comply with ASTM A 780.
3. Powder Coating: Immediately after cleaning and pretreating, apply TGIC polyester powder-coat finish, with a minimum dry film thickness of 2 mils (0.05 mm).
   a. Color and Gloss: As selected from manufacturer's full range.
4. Powder Coating: Immediately after cleaning and pretreating, apply 2-coat finish consisting of zinc-rich, **as directed**, epoxy prime coat and TGIC polyester topcoat, with a minimum dry film thickness of 2 mils (0.05 mm) for topcoat. Comply with coating manufacturer's written instructions to achieve a minimum total dry film thickness of 4 mils (0.10 mm).
   a. Color and Gloss: As selected from manufacturer's full range.
   b. Comply with surface finish testing requirements in ASTM F 2408 except change corrosion-resistance requirement to 3000 hours without failure, **as directed**.
5. High-Performance Coating: Apply epoxy primer, epoxy intermediate coat, and polyurethane topcoat to prepared surfaces. Comply with coating manufacturer's written instructions and with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Apply at spreading rates recommended by coating manufacturer.
   a. Match approved Samples for color, texture, and coverage. Remove and refinish, or recoat work that does not comply with specified requirements.

1.3 EXECUTION

A. Examination
1. Examine areas and conditions, with Installer present, for compliance with requirements for site clearing, earthwork, pavement work, construction layout, and other conditions affecting performance of the Work.
2. Do not begin installation before final grading is completed unless otherwise permitted by the Owner.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation
1. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet (152.5 m) or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

C. Decorative Fence Installation
1. Install fences according to manufacturer's written instructions.
   OR
   Install fences by setting posts as indicated and fastening rails and infill panels to posts. Peen threads of bolts after assembly to prevent removal, **as directed**.

2. Post Excavation: Drill or hand-excavate holes for posts in firm, undisturbed soil. Excavate holes to a diameter of not less than 4 times post size and a depth of not less than 24 inches (600 mm) plus 3 inches (75 mm) for each foot (300 mm) or fraction of a foot (300 mm) that fence height exceeds 4 feet (1200 mm).
3. Post Setting: Set posts in concrete **OR** with mechanical anchors **OR** by mechanically driving into soil, **as directed**, at indicated spacing into firm, undisturbed soil.
   a. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
   b. Concrete Fill: Place concrete around posts and sleeves, **as directed**, and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
      1) Exposed Concrete: Extend 2 inches (50 mm) above grade. Finish and slope top surface to drain water away from post.
      2) Concealed Concrete: Top 2 inches (50 mm) below grade as indicated on Drawings to allow covering with surface material. Slope top surface of concrete to drain water away from post.
   c. Posts Set in Concrete: Extend post to within 6 inches (150 mm) of specified excavation depth, but not closer than 3 inches (75 mm) to bottom of concrete.
   d. Posts Set into Concrete in Sleeves: Use galvanized-steel pipe sleeves with inside diameter at least 3/4 inch (20 mm) larger than outside diagonal dimension of post, preset and anchored into concrete for installing posts.
      1) Extend posts at least 5 inches (125 mm) into sleeve.
      2) After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink grout, mixed and placed to comply with grout manufacturer's written instructions; shape and smooth to shed water. Finish and slope top surface of grout to drain water away from post.
   e. Posts Set into Voids in Concrete: Form or core drill holes not less than 3/4 inch (20 mm) larger than outside diagonal dimension of post.
      1) Extend posts at least 5 inches (125 mm) into concrete.
      2) Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink grout, mixed and placed to comply with grout manufacturer's written instructions. Finish and slope top surface of grout to drain water away from post.
   f. Mechanically Driven Posts: Drive into soil to depth of 30 inches (762 mm) **OR** 36 inches (914 mm), **as directed**. Protect post top to prevent distortion.
   g. Space posts uniformly at 6 feet (1.83 m) **OR** 8 feet (2.44 m), **as directed**, o.c.

D. Gate Installation
1. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

E. Gate Operator Installation
1. General: Install gate operators according to manufacturer's written instructions, aligned and true to fence line and grade.
2. Excavation for Support Posts **OR** Pedestals **OR** Concrete Bases, **as directed**: Hand-excavate holes for bases, in firm, undisturbed soil to dimensions and depths and at locations as required by gate operator component manufacturer's written instructions and as indicated.
3. Concrete Bases: Cast-in-place or precast concrete, depth not less than 12 inches (300 mm) **OR** 6 to 12 inches (150 to 300 mm) below frost line, **as directed**, dimensioned and reinforced according to gate operator component manufacturer's written instructions and as indicated on Drawings.
4. Vehicle Loop Detector System: Cut grooves in pavement, **as directed**, and bury and seal wire loop according to manufacturer's written instructions. Connect to equipment operated by detector.

5. Comply with NFPA 70 and manufacturer's written instructions for grounding of electric-powered motors, controls, and other devices.

F. Grounding And Bonding
1. Fence Grounding: Install at maximum intervals of 1500 feet (450 m) except as follows:
   a. Fences within 100 Feet (30 m) of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet (225 m).
      1) Gates and Other Fence Openings: Ground fence on each side of opening.
         a) Bond metal gates to gate posts.
         b) Bond across openings, with and without gates, except openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches (460 mm) below finished grade.
2. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet (45 m) on each side of crossing.
3. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2 unless otherwise indicated.
4. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches (150 mm) below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at the grounding location.
5. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.
6. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
   a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
   b. Make connections with clean, bare metal at points of contact.
   c. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
   d. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
   e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
7. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

G. Field Quality Control
1. Grounding-Resistance Testing: Engage a qualified testing agency to perform tests and inspections.
   a. Grounding-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure grounding resistance not less than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural grounding resistance. Perform tests by two-point method according to IEEE 81.
   b. Excessive Grounding Resistance: If resistance to grounding exceeds specified value, notify the Owner promptly. Include recommendations for reducing grounding resistance and a proposal to accomplish recommended work.
   c. Report: Prepare test reports certified by a testing agency of grounding resistance at each test location. Include observations of weather and other phenomena that may affect test results.

H. Adjusting
1. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire

operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

2. Automatic Gate Operators: Energize circuits to electrical equipment and devices. Adjust operators, controls, safety devices, alarms, **as directed**, and limit switches.
   a. Hydraulic Operators: Purge Operating System, Adjust Pressure And Fluid Levels, And Check For Leaks.
   b. Operational Test: After Electrical Circuitry Has Been Energized, Start Units To Confirm Proper Motor Rotation And Unit Operation.
   c. Test And Adjust Controls, Alarms, **as directed**, And Safeties. Replace Damaged And Malfunctioning Controls And Equipment.
3. Lubricate hardware, gate operators, **as directed**, and other moving parts.

I. Demonstration
   1. Train Owner's personnel to adjust, operate, and maintain gates.

END OF SECTION 32 31 19 00

Task	Specification	Specification Description
32 31 19 00	01 22 16 00	No Specification Required
32 31 19 00	32 31 13 13	High-Security Chain-Link Fences And Gates
32 31 23 00	01 22 16 00	No Specification Required

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SECTION 32 31 29 00 - PERMANENT WOOD FENCING

1.1 GENERAL

A. Description Of Work
1. The specification covers the furnishing and installation of materials for repair and maintenance of permanent wood fencing. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals: Shop drawings shall be submitted for approval.

1.2 PRODUCTS

A. Review MSDS and Manufacturers Application Instructions.

B. Pickets:
1. Size: Wood For picket shall match the existing fencing in material, configuration, dimensions, texture, and finishes,
2. Attachment: Hot-dipped galvanized nails complying with Fed. Spec. FF-N-105 shall be used to fasten pickets to rails.

C. Framework:
1. Line Posts: 4 x 4 of required length to match existing post height and extend into the ground as required to ensure rigid installation.
2. Terminal and Corner Posts: 4 x 4 of required length.
3. Gate Posts: 4 x 6 and of the length required for firm embedment to resist gate action.
4. Top Rail: 2 x 4 of length required to span between posts.
5. Where bracing is required, it shall match top and bottom rails in dimension and finish.
6. Metal Posts and Rails: Solid mild steel galvanized in compliance with ASTM A 123 of the length and style required to match existing.

D. Gates:
1. Frame: 2 x 4 members with attached pickets. Configuration of gate shall match that of existing gates.
2. Bracing: Single 2 x 4 running diagonally across the gate to opposite corners of the frame.
3. Hardware: Hinges, latches, and other hardware shall be hot dipped galvanized and of configurations to match existing hardware. Bolts and nuts shall comply with ASTM A 307 and galvanized in compliance with ASTM A 153.

E. Finish: All wood fence members shall be given a pressure preservative treatment in a closed retort. The treatment shall comply with Fed. Spec. TT-W-571. Wood cut or sawed after treatment shall have the cut surfaces well brush-coated with the preservative used in the treatment. Paint to match existing after treatment and installation.

1.3 EXECUTION

A. Posts: Hold in line in a true vertical position by temporary bracing until backfilling is completed. Compact by hand tamping or other suitable methods to a density comparable to that of adjacent ground. Posts of fencing that are higher than four feet and exposed to strong winds and posts at all gates shall be of heavy construction and shall be embedded in concrete.

B. Rails: Install at the height and in the manner required to match existing fencing, and secure to post with fasteners similar to existing.

C. Pickets: Space, attach, and position to match existing pattern and attachment methods.

D. Accessories: Install to match existing conditions.

END OF SECTION 32 31 29 00

Task	Specification	Specification Description
32 31 29 00	01 22 16 00	No Specification Required

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SECTION 32 32 13 00 - SEGMENTAL RETAINING WALLS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for segmental retaining walls. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes single- and multiple- depth segmental retaining walls with and without soil reinforcement.

C. Performance Requirements
1. Basis of Design: Design of segmental retaining walls is based on products indicated. If comparable products of other manufacturers are proposed, provide engineering design for proposed products, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Delegated Design: Design segmental retaining walls, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
3. Structural Performance: Engineering design shall be based on the following loads and be according to NCMA's "Design Manual for Segmental Retaining Walls."
4. Gravity loads due to soil pressures resulting from grades and sloped backfill indicated.
   a. Superimposed loads (surcharge) indicated on Drawings.
5. Seismic Performance: Engineering design shall be based on the following loads and factors and be according to NCMA's "Segmental Retaining Walls - Seismic Design Manual."
   a. Gravity loads due to soil pressures resulting from grades and sloped backfill indicated.
   b. Superimposed loads (surcharge) indicated on Drawings.
   c. Horizontal Peak Ground Acceleration (A) for Project: **As directed**.

D. Preconstruction Testing
1. Preconstruction Testing Service: Engage a qualified testing agency to perform the following preconstruction testing:
   a. Test soil reinforcement and backfill materials for pullout resistance according to ASTM D 6706.
   b. Test soil reinforcement and backfill materials for coefficient of friction according to ASTM D 5321.

E. Submittals
1. Product Data: For each type of product indicated.
2. Samples: For each color and texture of concrete unit required. Submit full-size units **OR** sections of units not less than 3 inches (75 mm) square, **as directed**.
   a. Include one full-size unit for each type of concrete unit required.
3. Delegated-Design Submittal: For segmental retaining walls indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   a. Compliance Review: Qualified professional engineer responsible for segmental retaining wall design shall review and approve submittals and source and field quality-control reports for compliance of materials and construction with design.
4. Product Certificates: For segmental retaining wall units and soil reinforcement, from manufacturer.

a. Include test data for shear strength between segmental retaining wall units according to ASTM D 6916.
b. Include test data for connection strength between segmental retaining wall units and soil reinforcement according to ASTM D 6638.

5. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for segmental retaining wall units and soil reinforcement.
   a. Include test data for freeze-thaw durability of segmental retaining wall units.
   b. Include test data for shear strength between segmental retaining wall units according to ASTM D 6916.
   c. Include test data for connection strength between segmental retaining wall units and soil reinforcement according to ASTM D 6638.

F. Quality Assurance
1. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.
2. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects.
   a. Build mockup of segmental retaining wall as shown on Drawings **OR** approximately 72 inches (1800 mm) long by not less than 36 inches (900 mm) high above finished grade at front of wall, **as directed**.
      1) Include typical soil reinforcement.
      2) Include typical base and cap or finished top construction.
      3) Include backfill to typical finished grades at both sides of wall.
      4) Include typical end construction at one end of mockup.
      5) Include 36-inch (900-mm) return at 1 end of mockup, with typical corner construction.
   b. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
3. Preinstallation Conference: Conduct conference at Project site.
   a. Review methods and procedures related to segmental retaining walls including, but not limited to, the following:
      1) Structural load limitations.
      2) Construction schedule. Verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
      3) Field quality-control procedures.

G. Delivery, Storage, And Handling
1. Store and handle concrete units and accessories to prevent deterioration or damage due to contaminants, breaking, chipping, or other causes.
2. Store geosynthetics in manufacturer's original packaging with labels intact. Store and handle geosynthetics to prevent deterioration or damage due to sunlight, chemicals, flames, temperatures above 160 deg F (71 deg C) or below 32 deg F (0 deg C), and other conditions that might damage them. Verify identification of geosynthetics before using and examine them for defects as material is placed.

1.2 PRODUCTS

A. Segmental Retaining Wall Units
1. Concrete Units: ASTM C 1372, Normal Weight, except that maximum water absorption shall not exceed 7 percent by weight and units shall not differ in height more than plus or minus 1/16 inch (1.6 mm) from specified dimension.
   a. Provide units that comply with requirements for freeze-thaw durability.
   b. Provide units that interlock with courses above and below by means of integral lugs or lips, pins, clips, or hollow cores filled with drainage fill.
2. Color: As selected from manufacturer's full range.

3. Shape and Texture: Provide units of basic shape and dimensions indicated with machine-split textured **OR** smooth, **as directed**, exposed faces.
4. Shape and Texture: Provide units matching basic shape, dimensions, and face texture indicated by referencing manufacturer's pattern designation.
5. Shape and Texture: Provide units of any basic shape and dimensions that will produce segmental retaining walls of dimensions and profiles indicated without interfering with other elements of the Work and with machine-split textured, flat exposed face **OR** shaped exposed face with deeply beveled vertical edges, **as directed**.
6. Batter: Provide units that offset from course below to provide at least 1:24 **OR** 1:16 **OR** 1:14 **OR** 1:8 **OR** 1:5, **as directed**, batter.
7. Cap Units: Provide cap units of shape indicated **OR** same shape as other units, **as directed**, with smooth, as-cast top surfaces without holes or lugs.
8. Special Units: Provide corner units, end units, and other shapes as needed to produce segmental retaining walls of dimensions and profiles indicated and to provide texture on exposed surfaces matching face **OR** as indicated, **as directed**.

B. Installation Materials
1. Pins: Product supplied by segmental retaining wall unit manufacturer for use with units provided, made from nondegrading polymer reinforced with glass fibers.
2. Clips: Product supplied by segmental retaining wall unit manufacturer for use with units provided, made from nondegrading polymer reinforced with glass fibers.
3. Cap Adhesive: Product supplied or recommended by segmental retaining wall unit manufacturer for adhering cap units to units below.
4. Leveling Base: Comply with requirements in Division 31 Section "Earth Moving" for base material **OR** Division 33 Section "Subdrainage" for drainage fill, **as directed**.
   a. Leveling Course: Lean concrete with a compressive strength of not more than 500 psi (3.4 MPa).
5. Drainage Fill: Comply with requirements in Division 33 Section "Subdrainage".
6. Reinforced-Soil Fill: ASTM D 2487; GW, GP, SW, SP, and SM soil classification groups or a combination of these groups; free of debris, waste, frozen materials, vegetation, and other deleterious matter; meeting the following gradation according to ASTM C 136: 20 to 100 percent passing No. 4 (4.75-mm) sieve, 0 to 60 percent passing No. 40 (0.425-mm) sieve, 0 to 35 percent passing No. 200 (0.075-mm) sieve, and with fine fraction having a plasticity index of less than 20.
7. Nonreinforced-Soil Fill: Comply with requirements in Division 31 Section "Earth Moving" for satisfactory soils.
8. Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent.
   a. Apparent Opening Size: No. 70 to 100 (0.212- to 0.150-mm) sieve, maximum; ASTM D 4751.
   b. Minimum Grab Tensile Strength: 110 lb (49.9 kg); ASTM D 4632.
   c. Minimum Weight: 4 oz./sq. yd. (132 g/sq. m).
9. Subdrainage Pipe and Filter Fabric: Comply with requirements in Division 33 Section "Subdrainage".
   a. Product Type: Knitted or woven geogrid made from polyester yarns with a protective coating **OR** Molded geogrid made from high-density polyethylene **OR** Woven geotextile made from polyamides, polyesters, or polyolefins, **as directed**.

C. Source Quality Control
1. Direct manufacturer to test and inspect each roll of soil reinforcement at the factory for minimum average roll values for geosynthetic index property tests, including the following:
   a. Weight.
   b. Roll size.
   c. Grab or single-rib strength.
   d. Aperture opening.
   e. Rib or yarn size.

1.3 EXECUTION

A. Examination
1. Examine areas and conditions, with Installer present, for compliance with requirements for excavation tolerances, condition of subgrades, and other conditions affecting performance of segmental retaining walls.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Retaining Wall Installation
1. General: Place units according to NCMA's "Segmental Retaining Wall Installation Guide" and segmental retaining wall unit manufacturer's written instructions.
   a. Lay units in running bond **OR** bond pattern indicated, **as directed**.
   b. Form corners and ends by using special units **OR** cutting units with motor-driven saw **OR** splitting units with mason's hammer and chisel, **as directed**.
2. Leveling Base: Place and compact base material to thickness indicated and with not less than 95 percent maximum dry unit weight according to ASTM D 698.
   a. Leveling Course: At Contractor's option, unreinforced lean concrete may be substituted for upper 1 to 2 inches (25 to 50 mm) of base **OR** Place unreinforced lean concrete over leveling base 1 to 2 inches (25 to 50 mm) thick, **as directed**. Compact and screed concrete to a smooth, level surface.
3. First Course: Place first course of segmental retaining wall units for full length of wall. Place units in firm contact with each other, properly aligned and level.
   a. Tamp units into leveling base as necessary to bring tops of units into a level plane.
4. Subsequent Courses: Remove excess fill and debris from tops of units in course below. Place units in firm contact, properly aligned, and directly on course below.
   a. For units with lugs designed to fit into holes in adjacent units, lay units so lugs are accurately aligned with holes, and bedding surfaces are firmly seated on beds of units below.
   b. For units with lips at front of units, slide units as far forward as possible for firm contact with lips of units below.
   c. For units with lips at bottom rear of units, slide units as far forward as possible for firm contact of lips with units below.
   d. For units with pins, install pins and align units.
   e. For units with clips, install clips and align units.
5. Cap Units: Place cap units and secure with cap adhesive.

C. Fill Placement
1. General: Comply with requirements in Division 31 Section "Earth Moving", NCMA's "Segmental Retaining Wall Installation Guide," and segmental retaining wall unit manufacturer's written instructions.
2. Fill voids between and within units with drainage fill. Place fill as each course of units is laid.
3. Place, spread, and compact drainage fill and soil fill in uniform lifts for full width and length of embankment as wall is laid. Place and compact fills without disturbing alignment of units. Where both sides of wall are indicated to be filled, place fills on both sides at same time. Begin at wall and place and spread fills toward embankment.
   a. Use only hand-operated compaction equipment within 48 inches (1200 mm) of wall, or one-half of height above bottom of wall, whichever is greater.
   b. Compact reinforced-soil fill to not less than 95 percent maximum dry unit weight according to ASTM D 698.
      1) In areas where only hand-operated compaction equipment is allowed, compact fills to not less than 90 percent maximum dry unit weight according to ASTM D 698.
      2) In areas where fill height exceeds 15 feet (4.5 m), compact reinforced-soil fill that will be more than 15 feet (4.5 m) below finished grade to not less than 98 percent maximum dry unit weight according to ASTM D 698.

3) In areas where fill height exceeds 30 feet (9 m), compact reinforced-soil fill that will be more than 30 feet (9 m) below finished grade to not less than 100 percent maximum dry unit weight according to ASTM D 698.

c. Compact nonreinforced-soil fill to comply with Division 31 Section "Earth Moving".

4. Place drainage geotextile against back of wall and place layer of drainage fill at least 12 inches (300 mm) **OR** 6 inches (150 mm), **as directed**, wide behind drainage geotextile to within 12 inches (300 mm) of finished grade. Place another layer of drainage geotextile between drainage fill and soil fill.
5. Place a layer of drainage fill at least 12 inches (300 mm) **OR** 6 inches (150 mm), **as directed**, wide behind wall to within 12 inches (300 mm) of finished grade. Place a layer of drainage geotextile between drainage fill and soil fill.
6. Wrap subdrainage pipe with filter fabric and place in drainage fill as indicated, sloped not less than 0.5 percent to drain.
7. Place impervious fill over top edge of drainage fill layer.
8. Slope grade at top of wall away from wall unless otherwise indicated. Slope grade at base of wall away from wall. Provide uniform slopes that will prevent ponding.
9. Place soil reinforcement in horizontal joints of retaining wall where indicated and according to soil-reinforcement manufacturer's written instructions. Embed reinforcement a minimum of 8 inches (200 mm) into retaining wall and stretch tight over compacted backfill. Anchor soil reinforcement before placing fill.
   a. Place additional soil reinforcement at corners and curved walls to provide continuous reinforcement.
   b. Place geosynthetics with seams, if any, oriented perpendicular to segmental retaining walls.
   c. Do not dump fill material directly from trucks onto geosynthetics.
   d. Place at least 6 inches (150 mm) of fill over reinforcement before compacting with tracked vehicles or 4 inches (100 mm) before compacting with rubber-tired vehicles.
   e. Do not turn vehicles on fill until first layer of fill is compacted and second layer is placed over each soil-reinforcement layer.

D. Construction Tolerances
1. Variation from Level: For bed-joint lines along walls, do not exceed 1-1/4 inches in 10 feet (32 mm in 3 m), 3 inches (75 mm) maximum.
2. Variation from Indicated Batter: For slope of wall face, do not vary from indicated slope by more than 1-1/4 inches in 10 feet (32 mm in 3 m).
3. Variation from Indicated Wall Line: For walls indicated as straight, do not vary from straight line by more than 1-1/4 inches in 10 feet (32 mm in 3 m).

E. Field Quality Control
1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
2. Comply with requirements in Division 31 Section "Earth Moving" for field quality control.
   a. In each compacted backfill layer, perform at least 1 field in-place compaction test for each 150 feet (45 m) or less of segmental retaining wall length.
   b. In each compacted backfill layer, perform at least 1 field in-place compaction test for each 24 inches (600 mm) of fill depth and each 50 feet (15 m) or less of segmental retaining wall length.

F. Adjusting
1. Remove and replace segmental retaining wall construction of the following descriptions:
   a. Broken, chipped, stained, or otherwise damaged units. Units may be repaired if the Owner approves methods and results.
   b. Segmental retaining walls that do not match approved Samples.
   c. Segmental retaining walls that do not comply with other requirements indicated.
2. Replace units so segmental retaining wall matches approved Samples and mockups, complies with other requirements, and shows no evidence of replacement.

END OF SECTION 32 32 13 00

Task	Specification	Specification Description
32 32 16 00	03 41 23 00	Plant-Precast Structural Concrete
32 32 23 13	32 32 13 00	Segmental Retaining Walls
32 32 26 00	32 32 13 00	Segmental Retaining Walls
32 32 29 00	32 32 13 00	Segmental Retaining Walls
32 32 53 00	32 32 13 00	Segmental Retaining Walls

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SECTION 32 33 13 00 - MISCELLANEOUS SITE AND STREET FURNISHINGS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of miscellaneous site and street furnishings. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Shop Drawings: Fabrication and installation drawings for each type of product indicated.
2. Product Data: For each type of product indicated.

C. Qualification Of Welders
1. Qualify welders in accordance with AWS D1.1 using procedures, materials, and equipment of the type required for the work.

D. Delivery, Storage, And Protection
1. Protect from corrosion, staining, and other types of damage. Store items in an enclosed area free from contact with soil and weather. Remove and replace damaged items with new items.

1.2 PRODUCTS

A. Precast Benches
1. Design precast benches in accordance with manufacturer's standards, size as indicated. Finish and color as indicated selected from manufacturer's standards.
2. Glass Fiber Reinforced Concrete (GFRC) Benches
   a. Provide glass fiber reinforced concrete (GFRC) benches at locations as directed. Comply with PCI MNL-128 recommended practice for glass fiber reinforced concrete, including Appendix G, Polymer Modified Glass Fiber Reinforced Concrete Panels.
   b. Design precast benches to sustain a live load of not less than 200 pounds per square foot (10 kPa), constructed of minimum 3000 psi concrete with ASTM C 150 cement, white or grey color consistent with final finish, using alkali resistant (AR) glass fibers produced specifically for use in glass fiber reinforced concrete, minimum three percent glass fiber content. Aggregate shall be clear silica sand aggregate; washed, dried and free from deleterious materials. Provide type with successful history of uses in GFRC fabrication standard with the manufacturer. Provide manufacturer's standard acrylic thermoplastic copolymer admixture.
   c. Provide factory finished units standard with the manufacturer; texture and color as selected.
3. Precast Concrete/Cast Stone Benches
   a. Provide reinforced precast concrete benches consisting of a mixture of cement, aggregates and mineral colors suitable for exterior use, located as directed.
   b. Design benches to sustain a live load of not less than 200 pounds per square foot (10 kPa).
      1) Portland cement: ASTM C150 Type I, II, or III.
      2) Aggregate: ASTM C33, maximum size 3/4 inch (19 mm).
      3) Reinforcing steel: ASTM A615/A615M
      4) Galvanized wire mesh: ASTM A1064
      5) Integral color: ASTM C979, pure mineral oxide, limeproof and non-fading.
      6) Provide minimum 5000 psi (35 MPa) 28 day compressive strength concrete, maximum five percent absorption.

7) Admixture: ASTM C260 for air-entraining.

B. Precast Concrete Bicycle Rack
1. Provide one-piece precast concrete bicycle rack base with embedded galvanized metal hitching loops. Design bicycle rack with wheel notches for bike support and wheel locking device.

C. Precast Concrete Bollards
1. Provide reinforced concrete bollards 12 inch (300 mm) **OR** 18 inch (450 mm), **as directed**, square **OR** round, **as directed**, height as indicated, suitable for ground mount installation. Provide exposed aggregate or sandblast finish as indicated; manufacturer's standard clear acrylic sealer.
   a. Portland cement: ASTM C150, Type I II or III.
   b. Aggregate: ASTM C33, maximum size 3/4 inch (19 mm).
   c. Reinforcing steel: ASTM A615/A615M.
   d. Integral color: ASTM C979, pure mineral oxide, limeproof and non-fading.
   e. Concrete strength: 5000 psi (35 MPa), 28 day minimum compressive strength.
   f. Admixture: ASTM C260 for air-entraining.

D. Planters, Receptacles, Ash Receptacles
1. Provide for waste receptacles spun aluminum **OR** reinforced fiberglass, **as directed**, flat **OR** domed, **as directed**, tops and removable semi-rigid plastic liner insert. Provide top-mounted ash trays for ash receptacles.
2. Glass Fiber Reinforced Concrete (GFRC) Precast:
   a. Provide glass fiber reinforced concrete (GFRC) precast planters/waste receptacles/ash receptacles at locations as directed. Comply with PCI MNL-117 and PCI MNL-128.
   b. Materials: Provide manufacturer's standard shell thickness of 3/8 to 5/8 inch (9 to 16 mm).
      1) Cement: ASTM C150, use only one brand and type of cement throughout the Project.
      2) Glass Fibers: Alkali resistant (AR) glass fibers produced specifically for use in glass fiber reinforced concrete. Glass content of GFRC unit to be a minimum of three percent.
      3) Aggregates: clear silica sand; washed, dried, and free from deleterious materials; provide type with successful history of use in GFRC and as standard with the manufacturer.
      4) Compressive Strength: Minimum 3000 psi (20/25 MPa) 28 day strength.
      5) Density: Approximately 120 pcf (1921 kg/cu. m).
      6) Polymer Admixture: Manufacturer's standard acrylic thermoplastic copolymer.
   c. Finishes: Provide factory finished units with manufacturer's standard texture or sandblasted finish as selected.
      1) Cement: White or grey as consistent with final finish.
3. Precast Concrete/Cast Stone Planters
   a. Provide reinforced precast concrete planters/waste receptacles/ash receptacles consisting of a mixture of cement, aggregates, and mineral colors suitable for exterior use as located on the drawings. Provide manufacturer's standard exposed aggregate or sandblast finish (with clear acrylic coating) as selected.
      1) Portland Cement: ASTM C150, gray, Type I.
      2) Aggregate: ASTM C33, crushed limestone and sand.
      3) Galvanized Steel Mesh: ASTM A1064.
      4) Integral Color: ASTM C979, pure mineral oxide, limeproof and non-fading.
      5) Concrete Strength: 4000 psi (30 MPa) minimum compressive strength at 28 days.
      6) Admixture: ASTM C260 for air-entraining.
4. Wood Planters
   a. Provide manufacturer's standard wood planter/waste receptacle/ash receptacles fabricated of 3/4 inch (19 mm) thick tongue and grooved wood slats permanently bonded with

fiberglass interior shell. Provide wood top trim for square planters and fiberglass top trim for round planters.
1) Wood Species: As directed.
2) Fiberglass: Molded with multiple laminations of glass fiber impregnated with polyester isophthalic thermosetting resins with a finish of 12-15 mil (0.30-0.38 mm) color impregnated polyester gel coat.
3) Metal Frame: Black color-coated steel frame.

5. Wood Planters with Metal Frames
   a. Provide manufacturer's standard wood planter/waste receptacle/ash receptacle with galvanized steel welded frames, and nominal 2 inch (50 mm) tongue and grooved, beveled or square cut wood staves. Attach wood staves to metal frame from inside with steel plated screws.
      1) Wood species: Kiln dried, maximum 19 percent moisture content, species as directed.
      2) Metal frame: Reinforced with steel bars as per manufacture's standard construction, black color factory finish coated.
      3) Bottom: 1/4 inch (6.25 mm) exterior grade redwood with drain holes.
      4) Liners: Removable galvanized steel or manufacturer's standard.
      5) Tops: Hinged top opening, spun aluminum open top with molded rim, ash top.
6. Fiberglass Planters/Waste Receptacles/Ash Receptacles
   a. Provide reinforced fiberglass planters/waste receptacles/ash receptacles molded with multiple laminations of glass fiber impregnated with polyester isophthalic thermosetting resins; with 12-15 mil (0.30-0.38 mm) color impregnated polyester gel coat finish; minimum thickness of 1/4 inch (6.25 mm); color as selected.
   b. Receptacles:
      1) Shall be manufactured by Maglin,
      2) Color: Malaga Green

E. Shelters
1. AISC S342L; AISC S335. Provide prefabricated shelter systems to meet design conditions indicated. Shelter design shall conform to all applicable State and Local Building Codes and shall meet manufacturer's standards of construction and materials. Shelter systems shall be preglazed, pre-drilled and pre-cut, shipped with all hardware and accessories necessary for complete field assembly.
2. Framing Systems: Framing system; columns, rafters, ridge, purlins and other structural framing members shall be aluminum/steel/wood as indicated. Manufacturer shall provide shop drawings and calculations prepared by a structural engineer.
   a. Extruded aluminum alloy tubing shall conform to ASTM B429 6063-T5 or 3003-H14, anodized or powder coat finish, color as directed. Framing sizes and configurations shall be as required for size of structure indicated meeting manufacturer's standards and applicable building codes.
   b. Structural steel shall conform to ASTM A36/A36M or ASTM A500, 36,000 psi (248 MPa) yield strength and 58,000 psi (400 MPa) tensile strength, factory finished with rust inhibited primer and powder coat conforming to ASTM D3451. Framing sizes and configurations shall be as required for size of structure indicated meeting manufacturer's standard and applicable building codes.
   c. Wood framing system shall consist of surfaced four sides (S4S), #2 grade southern yellow pine solid timber columns with eased edges, pressure treated CCA (Copper Chrome Arsinate) 0.6 PCF (9.6 kg/cu.m) against decay, fungi and insect infestation, surfaced four sides (S4S), #1 grade, southern pine, glue-laminated columns manufactured in accordance with ANSI/AITC A190.1 and AITC certified glue-laminated structural grade southern yellow pine beams, rafters and purlins, factory sealed and individually wrapped for protection during shipment. Factory stain all wood members prior to shipment.
3. Roof Panels/Decking: Provide manufacturer's standard molded acrylic translucent roof panel, OR standing seam metal roof panel, OR wood decking, OR V-beam aluminum roof panels, OR

FRP roof panels, as indicated. Materials shall be factory finished and shipped with all necessary fasteners and accessories as required for complete site assembly.

4. Glazing: Factory installed in separate structural window frames, gasketed and glazed as per manufacturer's standard, interchangeable, glazing system. Provide 1/4 inch (6.25 mm) acrylic sheet, OR tempered glass, OR polycarbonate plastic sheet OR mar-resistant polycarbonate plastic sheet, clear OR color.

F. Tables

1. Precast Concrete Tables: Provide reinforced precast concrete tables with smooth tops; minimum 4500 psi (35 MPa) concrete, 28 day minimum compressive strength, consisting of a mixture of cement, aggregates, and mineral colors suitable for exterior use as located on the drawings. Provide manufacturer's standard exposed aggregate or sandblast finish with clear acrylic coating.
   a. Portland cement: ASTM C150, gray, Type I.
   b. Aggregate: ASTM C33, washed limestone and sand.
   c. Galvanized wire mesh: 14 gage (1.9 mm), 2 by two inch (50 by 50 mm).
   d. Welded wire fabric: ASTM A1064.
   e. Reinforcing steel: ASTM A615/A615M.
   f. Integral color: ASTM C979, pure mineral oxide, limeproof and non-fading.
   g. Admixture: ASTM C260 for air-entraining..
2. Fiberglass Tables: Provide reinforced fiberglass table tops molded with multiple laminations of glass fiber impregnated with polyester isophthalic thermosetting resins, minimum thickness of 1/4 inch (6.25 mm) with 12-15 mil (0.30-0.38 mm) thickness color impregnated polyester gel coat, color as selected.
   a. Steel pedestal base: ASTM A53 Schedule 40 steel pipe.
   b. Mounting: Type as indicated.
   c. Metal finish: Powder coating conforming to ASTM D3451 testing.
3. Perforated Steel Tables: Provide 14 gage (1.9 mm) **OR** 16 gage (1.6 mm), **as directed**, perforated steel sheet table tops with solid metal edges as per manufacturer's standard. Weld tops to base as required for frame support.
   a. Steel pedestal base: ASTM A53 Schedule 40 steel pipe, 2 3/8 inch (60 mm) O.D.
   b. Mounting: Type as indicated.
   c. Hardware: Zinc or cadium plated nuts, bolts, screws, and lock washers.
   d. Metal finish: Powder coating conforming to ASTM D3451 testing.
4. Wood Seats and Tables
   a. Provide manufacturer's standard wood seats and tables, minimum 1-5/8 inches (40 mm) thick with rounded edges, with wood or metal bases as indicated. Provide fasteners and accessories required for on site assembly. Kiln dry and pressure treat wood components to manufacturer's standard, maximum 19 percent moisture content. Pre-treat metal components and provide manufacturer's standard primer and powder coat finish complying with ASTM D3451, color as selected.
      1) Design wood tables to sustain a live load of not less than 200 pounds per square foot (10 kPa).
      2) Provide kiln dried, surfaced four sides (S4S), clear all sides wood slats of species and sizes indicated.
         a) Species: As directed.
         b) Nominal wood slat sizes: As directed.
   b. Support Base: Provide wood or metal support bases as per manufacturer's standard.
      1) Wood: Match in species, grade, grain, color and finish of the wood slats.
      2) Steel: ASTM A653/A653M.
      3) Cast grey iron: ASTM A 48/A48M, Class 30 or recycled cast grey iron ASTM A48/A48M, Class 25.
      4) Cast aluminum: ASTM B26/B26M or ASTM B108 as applicable.
      5) Design bases to support the loads imposed in the design of the tables.

G. Grates

1. Provide cast aluminum **OR** cast iron **OR** cast bronze **OR** punched steel **OR** stainless steel, **as directed**, tree grates in round **OR** square, **as directed**, model of sizes indicated on the drawings. Furnish complete with angle steel frames with finish to match tree grates.

H. Fabrication Finishes
1. Galvanizing: Hot-dip galvanize items specified to be zinc-coated, after fabrication where practicable. Galvanizing: ASTM A123/A123M, ASTM A153/A153M or ASTM A653/A653M, as applicable.
2. Galvanize: Anchor bolts, grating fasteners, washers, and parts or devices necessary for proper installation, unless indicated otherwise.
3. Repair of Zinc-Coated Surfaces: Repair damaged surfaces with galvanizing repair method and paint conforming to ASTM A780 or by the application of stick or thick paste material specifically designed for repair of galvanizing, as approved. Clean areas to be repaired and remove the slag from the welds. Heat surfaces to which stick or paste material is applied, with a torch to a temperature sufficient to melt the metallics in stick or paste; spread the molten material uniformly over surfaces to be coated and wipe the excess material off.
4. Pretreatment, Priming and Painting: Apply pretreatment, primer, and paint in accordance with manufacturer's printed instructions. On surfaces concealed in the finished construction or not accessible for finish painting, apply an additional prime coat to a minimum dry film thickness of 1.0 mil (0.03 mm). Tint additional prime coat with a small amount of tinting pigment.
5. Nonferrous Metal Surfaces: Protect by plating, anodic, or organic coatings.
6. Aluminum Surfaces
   a. Surface Condition: Before finishes are applied, remove roll marks, scratches, rolled-in scratches, kinks, stains, pits, orange peel, die marks, structural streaks, and other defects which will affect uniform appearance of finished surfaces.

1.3 EXECUTION

A. Installation
1. Install items at locations indicated, according to manufacturer's instructions. Items listed below require additional procedures.
   a. Assembly and Erection of Components: Items shall be shipped knocked-down (KD) ready for site assembly. Packaged components shall be complete including all accessories and hardware. Follow manufacturer's instructions for assembly and erection. Provide mounting bolts or hardware for mounting items to substrate.

B. Anchorage, Fastenings, And Connections
1. Provide anchorage where necessary for fastening furniture or furnishings securely in place. Include for anchorage not otherwise specified or indicated slotted inserts, expansion shields, and powder-driven fasteners, when approved for concrete; toggle bolts and through bolts for masonry; machine and carriage bolts for steel; through bolts, lag bolts, and screws for wood. Do not use wood plugs in any material. Provide non-ferrous attachments for non-ferrous metal. Make exposed fastenings of compatible materials, generally matching in color and finish, to which fastenings are applied. Conceal fastenings where practicable.

C. Built-In-Work
1. Form for anchorage metal work built-in with concrete or masonry, or provide with suitable anchoring devices as indicated or as required. Furnish metal work in ample time for securing in place as the work progresses.

D. Welding
1. Perform welding, welding inspection, and corrective welding, in accordance with AWS D1.1. Use continuous welds on all exposed connections. Grind visible welds smooth in the finished installation.

E. Finishes: Dissimilar Materials
1. Where dissimilar metals are in contact, protect surfaces with a coat conforming to FS TT-P-664 to prevent galvanic or corrosive action. Where aluminum is in contact with concrete, mortar, masonry, wood, or absorptive materials subject to wetting, protect with ASTM D1187, asphalt-base emulsion.

F. Bollards
1. Install in pipe sleeves embedded in concrete and filled with non-shrink grout or quick setting anchoring cement.

G. Shelters
1. Secure to the adjacent construction with the clip angles attached to the concrete. Secure to concrete with not less than two 1/2 inch (12 mm) diameter expansion bolts.
   a. Glazing: Factory install windows into separate structural frame. Miter corners and connect internally by extruded aluminum corner keys or screw bosses with tamper-proof stainless steel screws. Provide continuous gasketing around windows set to metal frames. Provide 1/2 to 3/4 inch (13 to 19 mm) deep pocket for polycarbonate glazing. Fully gasket and frame in independent interchangable factory assembled units. Affix to shelter frame with 3/16 inch (5 mm) shallow head aluminum rivets at approximately 13 1/4 inches (331 mm) on centers for full 360 degrees (6.28 rad), rivet from inside of shelter.
   b. Roof: Provide manufacturer's standard roof system including facia **OR** gutter, **as directed**, assembly, ensuring a weather-tight seal and installation.

END OF SECTION 32 33 13 00

Task	Specification	Specification Description
32 33 13 00	01 22 16 00	No Specification Required

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SECTION 32 33 23 00 - SITE FURNISHINGS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for site furnishings. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
   a. Seating.
   b. Tables.
   c. Bicycle racks.
   d. Bicycle lockers.
   e. Trash receptacles.
   f. Ash receptacles.
   g. Planters.
   h. Bollards.

C. Submittals
1. Product Data: For each type of product indicated.
2. Samples: For each type of exposed finish required.
3. Product Schedule: For site furnishings. Use same designations indicated on Drawings.
4. Material Certificates: For site furnishings, signed by manufacturers.
   a. Wood Preservative Treatment: Include certification by treating plant stating type of preservative solution and pressure process used, net amount of preservative retained, and compliance with applicable standards.
   b. Sustainably Harvested Wood: Include certification by manufacturer and from sources that participate in sustained yield programs.
   c. Recycled plastic.
5. Maintenance Data: For site furnishings to include in maintenance manuals.

1.2 PRODUCTS

A. Materials
1. Aluminum: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated; free of surface blemishes and complying with the following:
   a. Rolled or Cold-Finished Bars, Rods, and Wire: ASTM B 211 (ASTM B 211M).
   b. Extruded Bars, Rods, Wire, Profiles, and Tubes: ASTM B 221 (ASTM B 221M).
   c. Structural Pipe and Tube: ASTM B 429.
   d. Sheet and Plate: ASTM B 209 (ASTM B 209M).
   e. Castings: ASTM B 26/B 26M.
2. Steel and Iron: Free of surface blemishes and complying with the following:
   a. Plates, Shapes, and Bars: ASTM A 36/A 36M.
   b. Steel Pipe: Standard-weight steel pipe complying with ASTM A 53, or electric-resistance-welded pipe complying with ASTM A 135.
   c. Tubing: Cold-formed steel tubing complying with ASTM A 500.
   d. Mechanical Tubing: Cold-rolled, electric-resistance-welded carbon or alloy steel tubing complying with ASTM A 513, or steel tubing fabricated from steel complying with ASTM A 1011/A 1011M and complying with dimensional tolerances in ASTM A 500; zinc coated internally and externally.

e. Sheet: Commercial steel sheet complying with ASTM A 1011/A 1011M.
f. Perforated Metal: From steel sheet not less than 0.0747-inch (1.9-mm) **OR** 0.0897-inch (2.3-mm) **OR** 0.1196-inch (3.0-mm), **as directed**, nominal thickness; manufacturer's standard perforation pattern.
g. Expanded Metal: Carbon-steel sheets, deburred after expansion, and complying with ASTM F 1267.
h. Malleable-Iron Castings: ASTM A 47/A 47M, grade as recommended by fabricator for type of use intended.
i. Gray-Iron Castings: ASTM A 48/A 48M, Class 200.

3. Stainless Steel: Free of surface blemishes and complying with the following:
   a. Sheet, Strip, Plate, and Flat Bars: ASTM A 666.
   b. Pipe: Schedule 40 steel pipe complying with ASTM A 312/A 312M.
   c. Tubing: ASTM A 554.
4. Wood: Surfaced smooth on four sides with eased edges; kiln dried, free of knots, solid stock of species indicated.
   a. Wood Species: Manufacturer's standard.
      1) Douglas Fir: Clear Grade, vertical grain.
      2) Pine: Southern pine; No. 2 or better; preservative treated, kiln dried after treatment.
      3) Eastern White **OR** Red **OR** Yellow **OR** Cedar, **as directed**: Select Grade or better.
      4) Redwood: Clear all heart **OR** Construction heart or better, **as directed**, free-of-heart center.
      5) Teak (Tectona Grandis): Clear Grade. Provide wood obtained from sources that participate in a well-managed forest and chain-of-custody program certified by an independent agency accredited by FSC.
      6) Finish: Manufacturer's standard stain and transparent sealer **OR** transparent wood preservative treatment and sealer, **as directed**.
5. Fiberglass: Multiple laminations of glass-fiber-reinforced polyester resin with UV-light stable, colorfast, nonfading, weather- and stain-resistant, colored polyester gel coat, and manufacturer's standard finish.
6. Plastic: Color impregnated, color and UV-light stabilized, and mold resistant.
   a. Polyethylene: Fabricated from virgin plastic HDPE resin.
   b. Recycled Polyethylene: Fabricated from not less than 96 percent recycled, purified, fractional-melt plastic resin with not less than 90 percent recycled postconsumer waste by weight HDPE.
7. Anchors, Fasteners, Fittings, and Hardware: Stainless steel **OR** Brass **OR** Galvanized steel **OR** Zinc-plated steel **OR** Manufacturer's standard, corrosion-resistant-coated or noncorrodible materials, **as directed**; commercial quality, tamperproof, vandal and theft resistant **OR** concealed, recessed, and capped or plugged, **as directed**.
   a. Angle Anchors: For inconspicuously bolting legs of site furnishings to on **OR** below, **as directed** -grade substrate; one per leg **OR** extent as indicated, **as directed**.
   b. Antitheft Hold-Down Brackets: For securing site furnishings to substrate; two per unit **OR** extent as indicated on Drawings, **as directed**.
8. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107; recommended in writing by manufacturer, for exterior applications.
9. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound; resistant to erosion from water exposure without needing protection by a sealer or waterproof coating; recommended in writing by manufacturer, for exterior applications.
10. Galvanizing: Where indicated for steel and iron components, provide the following protective zinc coating applied to components after fabrication:
    a. Zinc-Coated Tubing: External, zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. (0.27 kg/sq. m) of zinc after welding, a chromate conversion coating, and a clear,

polymer film. Internal, same as external or consisting of 81 percent zinc pigmented coating, not less than 0.3 mil (0.0076 mm) thick.

b. Hot-Dip Galvanizing: According to ASTM A 123/A 123M, ASTM A 153/A 153M, or ASTM A 924/A 924M.

B. Seating And Tables

1. Frame: Cast aluminum **OR** Cast iron **OR** Steel **OR** Stainless steel **OR** Wrought iron **OR** Cedar **OR** Teak, **as directed**.
2. Seat **OR** Seat and Back, **as directed**:
   a. Material:
      1) Aluminum Sheet: Perforated **OR** Expanded, **as directed**, metal.
      2) Steel **OR** Painted Steel, **as directed**: Perforated metal **OR** Expanded metal **OR** Evenly spaced, parallel flat straps or bars **OR** Evenly woven, flat straps or bars **OR** Edge framed, evenly spaced, parallel rods or rolled bars, **as directed**.
      3) Stainless Steel: Perforated metal **OR** Expanded metal **OR** Evenly spaced, parallel flat straps or bars **OR** Evenly woven, flat straps or bars **OR** Edge framed, evenly spaced, parallel rods or rolled bars, **as directed**.
      4) Wood: Douglas fir **OR** Pine **OR** Cedar **OR** Redwood **OR** Teak, **as directed**; formed into evenly spaced parallel slats **OR** planks, **as directed**.
      5) Recycled **OR** Plastic **OR** iberglass, **as directed**, Planks: Evenly spaced, parallel.
      6) Recycled **OR** Plastic **OR** Fiberglass, **as directed**, Sheet: Solid **OR** Perforated, **as directed**.
   b. Seat Height: As indicated.
   c. Seat Surface Shape: Flat **OR** Contoured or dished, **as directed**.
   d. Overall Height: As indicated.
   e. Overall Width: As indicated.
   f. Overall Depth: As indicated.
   g. Arms: None **OR** One, as indicated **OR** Two, one at each end **OR** Three, one at each end and in center, **as directed**.
      1) Arm Material: Match frame **OR** seat, **as directed**.
   h. Seating Configuration: Multiple units as indicated.
      1) Straight **OR** Angled **OR** Curved, **as directed**, shape.
      2) Closed hexagon **OR** circle **OR** shape indicated, **as directed**, around a tree trunk **OR** planter **OR** light post, **as directed**.
3. Table Top:
   a. Material:
      1) Aluminum Sheet: Perforated **OR** Expanded**, as directed,** metal.
      2) Steel **OR** Painted Steel, **as directed**: Perforated metal **OR** Expanded metal **OR** Evenly spaced, parallel flat straps or bars **OR** Evenly woven, flat straps or bars **OR** Edge framed, evenly spaced, parallel rods or rolled bars, **as directed**.
      3) Stainless Steel: Perforated metal **OR** Expanded metal **OR** Evenly spaced, parallel flat straps or bars **OR** Evenly woven, flat straps or bars **OR** Edge framed, evenly spaced, parallel rods or rolled bars, **as directed**.
      4) Wood: Douglas fir **OR** Pine **OR** Cedar **OR** Redwood **OR** Teak, **as directed**; formed into evenly spaced parallel slats **OR** planks, **as directed**.
      5) Recycled **OR** Plastic **OR** Fiberglass, **as directed**, Planks: Evenly spaced, parallel.
      6) Recycled **OR** Plastic **OR** Fiberglass, **as directed**, Sheet: Solid **OR** Perforated, **as directed**.
   b. Surface Shape: Round **OR** Hexagon **OR** Shape indicated, **as directed**.
   c. Feature: Center umbrella hole.
4. Aluminum Finish: Mill finish **OR** Color coated, **as directed**.
   a. Color: As selected from manufacturer's full range.
5. Steel Finish: Galvanized and color **OR** PVC-color, **as directed**, coated.
   a. Color: As selected from manufacturer's full range.
6. Stainless-Steel Finish: Dull Satin No. 6.

7. Wood Finish: Unfinished **OR** Factory-applied transparent finish **OR** Factory-applied stain and transparent finish **OR** Factory-applied opaque finish **OR** Manufacturer's standard finish, **as directed**.
   a. Stain: Manufacturer's standard.
8. Fiberglass **OR** HDPE, **as directed**, Color: As selected from manufacturer's full range.
9. Graphics: Surface-applied **OR** Engraved **OR** Attached brass plaque with engraved, **as directed**, copy, content, and style per manufacturer's standard **OR** as indicated on Drawings, **as directed**.

C. Bicycle Racks
1. Bicycle Rack Construction:
   a. Frame: Aluminum **OR** Steel **OR** Galvanized steel **OR** Stainless steel **OR** Steel and redwood **OR** Steel and pine, **as directed**.
      1) Pipe **OR** Tubing, **as directed**, OD: Not less than 1-5/8 inches (41 mm) **OR** 2-3/8 inches (60 mm) **OR** 2-7/8 inches (73 mm) **OR** 4-1/2 inches (115 mm), **as directed**.
      2) Locking Bars: Solid round bar, not less than 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, in diameter.
   b. Style: Single-side parking **OR** Double-side parking **OR** Bollard **OR** As indicated, **as directed**.
      1) Capacity: Designed to accommodate no fewer than two **OR** three **OR** four, **as directed**, bicycles.
   c. Security: Designed to lock wheel and frame.
   d. Accessories: Base covers for each pipe and tubing anchored end **OR** Wheel stops, **as directed**.
   e. Installation Method: Freestanding **OR** Surface flange anchored at finished grade to substrate indicated **OR** Surface flange anchored below finished grade to substrate indicated **OR** Cast in concrete **OR** Bolted to cast-in anchor bolts **OR** Wall mounted **OR** As indicated, **as directed**.
2. Aluminum Finish: Mill finish **OR** Color coated, **as directed**.
   a. Color: As selected from manufacturer's full range.
3. Steel Finish: Galvanized **OR** Color coated, **as directed**.
   a. Color: As selected from manufacturer's full range.
4. Stainless-Steel Finish: Directional Satin No. 4.
5. Wood Finish: Unfinished **OR** Manufacturer's standard finish, **as directed**.

D. Bicycle Lockers
1. Bicycle Locker Construction:
   a. Locker: Molded one-piece fiberglass **OR** Sheet steel, 0.053 inch (1.4 mm) thick, **OR** Sheet steel, 0.053 inch (1.4 mm) thick, with perforated metal sides, **as directed,** with welded tubular steel frame.
   b. Door: Molded one-piece fiberglass **OR** Sheet steel, 0.053 inch (1.4 mm) thick, **as directed,** with tubular steel frame **OR** Match locker, **as directed**.
   c. View Window **OR** Grille, **as directed**: Lexan, 12 inches (305 mm) square **OR** Perforated metal, **as directed**.
   d. Lock: Manufacturer's standard **OR** Key lock with internal locking bar **OR** Coin/token lock, **as directed**.
      1) Provide four keys.
   e. Overall Height: As indicated.
   f. Overall Width: As indicated.
   g. Overall Depth: As indicated.
   h. Capacity: Designed to accommodate one **OR** two, **as directed**, bicycle(s).
   i. Installation Method: Locker anchored at finished grade to substrate indicated **OR** Locker anchored below finished grade to substrate indicated **OR** As indicated, **as directed**.
   j. Locker Configuration: Multiple **OR** Four, **as directed**, units as indicated, in straight row **OR** curved shape **OR** shape indicated, **as directed**.
2. Steel Finish: Color coated.

a. Color: As selected from manufacturer's full range.

3. Fiberglass Color: As selected from manufacturer's full range.

E. Trash And Ash Receptacles

1. Aluminum Facing Surrounds: Aluminum sheet **OR** Perforated aluminum sheet **OR** Grid in tubular frame **OR** Evenly patterned, parallel flat aluminum straps, bars, or tubular shapes **OR** Match benches, **as directed**.
2. Steel Facing Surrounds: Steel sheet **OR** Perforated-steel sheet **OR** Evenly patterned, parallel flat steel straps, bars, or tubular shapes **OR** Evenly patterned, parallel round steel rods, bars, or tubular shapes **OR** Grid in tubular frame **OR** Match benches, **as directed**.
3. Stainless-Steel Facing Surrounds: Steel sheet **OR** Perforated-steel sheet **OR** Evenly patterned, parallel flat steel straps, bars, or tubular shapes **OR** Evenly patterned, parallel round steel rods, bars, or tubular shapes **OR** Grid in tubular frame **OR** Match benches, **as directed**.
4. Wood Facing Surrounds: Evenly spaced, Douglas fir slats **OR** Evenly spaced pine slats **OR** Evenly spaced cedar slats **OR** Redwood panels **OR** Evenly spaced redwood slats **OR** Teak panels **OR** Evenly spaced teak slats **OR** Match benches, **as directed**.
5. Fiberglass Facing Surrounds: Molded fiberglass shape.
6. Plastic Facing Surrounds: Molded HDPE shape **OR** Evenly spaced HDPE slats **OR** Evenly spaced, recycled HDPE slats **OR** Match benches, **as directed**.
7. Support Frames: Steel **OR** Galvanized steel, **as directed**; welded.
8. Trash and Ash Receptacles:
   a. Receptacle Shape and Form: Round cylinder **OR** Round cylinder with tapered funnel top **OR** Round, tapered column **OR** Square column **OR** Rectangular column **OR** As indicated, **as directed**; with opening for depositing trash in lid or top **OR** side of lid or top **OR** receptacle side, **as directed**.
   b. Ash Receptacle Function: Uncovered receptacle with sand pan **OR** Uncovered receptacle with bowl and funnel **OR** Covered receptacle with sand pan **OR** Covered receptacle with bowl and screen **OR** Covered receptacle with slots **OR** Uncovered receptacle with sand pan attaching to side of trash receptacle, **as directed**, for depositing cigarette butts; fire-proof design; bowl and pan removable for cleaning.
   c. Lids and Tops: Matching facing panels **OR** Aluminum **OR** Steel **OR** HDPE **OR** Recycled HDPE, **as directed,** secured by cable or chain, hinged, swiveled, or permanently secured.
      1) Description: Flat rim ring lid with center opening **OR** Dome top **OR** Arched top **OR** Elevated flat or shallow dome rain-cap lid **OR** Combination ash sand pan and rim lid **OR** Combination ash sand pan and dome top **OR** Combination ash sand pan and elevated flat or shallow dome rain-cap lid, **as directed**.
      2) Opening for depositing trash covered by self-closing, spring-loaded-hinged, push-in **OR** rotating, **as directed**, weather flap.
   d. Inner Container: Aluminum **OR** Galvanized steel sheet **OR** Perforated-metal OR Fiberglass **OR** Rigid plastic, **as directed**, container with drain holes **OR** lift-out handles, **as directed**; designed to be removable and reusable.
   e. Disposable Liners: Provide receptacle designed to accommodate disposable liners.
   f. Capacity: Not less than 22 gal. (83 L) **OR** 28 gal. (106 L) **OR** 30 gal. (114 L) **OR** 32 gal. (121 L) **OR** 40 gal. (151 L) **OR** 55 gal. (208 L), **as directed**.
   g. Service Access: Removable lid or top **OR** Fixed lid or top, side access, **as directed**; inner container and disposable liner lift or slide out for emptying; lockable with padlock hasps **OR** keyed lock with two keys per receptacle **OR** self-latching hinge, **as directed**.
   h. Post Mount: Color-coated steel pipe; color to match receptacle **OR** Galvanized steel pipe **OR** Wood, **as directed**; for mounting one **OR** two **OR** three, **as directed,** receptacle(s).
   i. Ash Receptacle Accessories: Sand sifter **OR** Butt stub-out, **as directed**.
9. Aluminum Finish: Mill finish **OR** Color coated, **as directed**.
   a. Color: As selected from manufacturer's full range.
10. Steel Finish: Galvanized and color **OR** PVC-color, **as directed**, coated.
    a. Color: As selected from manufacturer's full range.
11. Stainless-Steel Finish: Dull Satin No. 6.

12. Wood Finish: Unfinished **OR** Factory-applied transparent finish **OR** Factory-applied stain and transparent finish **OR** Factory-applied opaque finish **OR** Manufacturer's standard finish, **as directed**.
    a. Stain: Manufacturer's standard.
13. Fiberglass **OR** HDPE, **as directed**, Color: As selected from manufacturer's full range.
14. Graphics: Surface-applied **OR** Engraved **OR** Attached brass plaque with engraved, **as directed**, copy, content, and style per manufacturer's standard **OR** as indicated on Drawings, **as directed**.
    a. Copy: Litter **OR** Trash **OR** Waste **OR** Recycle, **as directed**.

F. Planters
1. Aluminum Facing Surrounds: Aluminum sheet **OR** Perforated aluminum sheet **OR** Grid in tubular frame **OR** Evenly patterned, parallel flat aluminum, **as directed**, straps, bars, or tubular shapes **OR** Match benches, **as directed**.
2. Steel Facing Surrounds: Steel sheet **OR** Perforated-steel sheet **OR** Evenly patterned, parallel flat steel straps, bars, or tubular shapes **OR** Evenly patterned, parallel round steel rods, bars, or tubular shapes **OR** Grid in tubular frame **OR** Match benches, **as directed**.
3. Stainless-Steel Facing Surrounds: Steel sheet **OR** Perforated-steel sheet **OR** Evenly patterned, parallel flat steel straps, bars, or tubular shapes **OR** Evenly patterned, parallel round steel rods, bars, or tubular shapes **OR** Grid in tubular frame **OR** Match benches, **as directed**.
4. Wood Facing Surrounds: Evenly spaced, Douglas fir slats **OR** Evenly spaced pine slats **OR** Evenly spaced cedar slats **OR** Redwood panels **OR** Evenly spaced redwood slats **OR** Teak panels **OR** Evenly spaced teak slats **OR** Match benches, **as directed**.
5. Fiberglass Facing Surrounds: Molded fiberglass shape.
6. Plastic Facing Surrounds: Molded HDPE shape **OR** Evenly spaced HDPE slats **OR** Evenly spaced, recycled HDPE slats **OR** Match benches, **as directed**.
7. Support Frames: Steel **OR** Galvanized steel, **as directed**; welded.
8. Planter Shape and Form: Round cylinder **OR** Round cylinder with tapered funnel top **OR** Round, tapered column **OR** Square column **OR** Rectangular column **OR** As indicated, **as directed**.
9. Style: To match benches **OR** As indicated by manufacturer's designation, **as directed**.
10. Inner Container: Aluminum **OR** Galvanized steel sheet **OR** Fiberglass **OR** Rigid plastic, **as directed**, container with drain holes.
11. Capacity: Not less than 22 gal. (83 L) **OR** 28 gal. (106 L) **OR** 30 gal. (114 L) **OR** 32 gal. (121 L) **OR** 40 gal. (151 L) **OR** 55 gal. (208 L), **as directed**.
12. Installation Method: Freestanding **OR** Freestanding with weighted base **OR** Anchored to substrate indicated on Drawings **OR** Wall mounted **OR** Post mounted **OR** Mounted on elevated leg angles anchored at finished grade to substrate indicated on Drawings **OR** Mounted on elevated leg angles anchored below finished grade to substrate indicated on Drawings **OR** As indicated on Drawings, **as directed**.
    a. Post Mount: Color-coated steel pipe; color to match receptacle **OR** Galvanized steel pipe **OR** Wood, **as directed**; for mounting one **OR** two **OR** three, **as directed**, planter(s).
13. Aluminum Finish: Color coated.
    a. Color: As selected from manufacturer's full range.
14. Steel Finish: Galvanized and color **OR** PVC-color, **as directed**, coated.
    a. Color: As selected from manufacturer's full range.
15. Stainless-Steel Finish: Dull Satin No. 6.
16. Wood Finish: Unfinished **OR** Factory-applied transparent finish **OR** Factory-applied stained and transparent finish, **as directed**.
17. Fiberglass **OR** HDPE, **as directed**, Color: As selected from manufacturer's full range.
    a. Finish: Smooth **OR** Textured, **as directed**.

G. Bollards
1. Bollard Construction:
    a. Pipe **OR** Tubing **OR** Cast, **as directed** OD: Not less than 4-1/2 inches (115 mm), fluted, **as directed**.
        1) Steel: Schedule 40 **OR** 80, **as directed**, pipe.

2) Aluminum: Extruded pipe and tubes **OR** Castings, **as directed**.
3) Stainless Steel: Tubes **OR** Pipe, **as directed**.
4) Cast Iron: Tapered **OR** As indicated, **as directed**.

b. Round **OR** Square, **as directed**, Wood: Cedar, 8 inches (203 mm) square **OR** 10 inches (254 mm) in diameter, **as directed**.
c. Style: Manufacturer's standard **OR** Chamfered top **OR** Dome top **OR** Ornamental cap **OR** As indicated, **as directed**.
d. Accessories: Eye bolts.
e. Installation Method: Surface flange anchored at finished grade to substrate indicated **OR** Surface flange anchored below finished grade to substrate indicated **OR** Cast in concrete **OR** Bolted to cast-in anchor bolts **OR** As indicated, **as directed**.

2. Aluminum Finish: Mill finish **OR** Color coated, **as directed**.
   a. Color: As selected from manufacturer's full range.
3. Steel Finish: Galvanized **OR** Color coated, **as directed**.
   a. Color: As selected from manufacturer's full range.
4. Cast-Iron Finish: Manufacturer's standard **OR** Galvanized **OR** Color coated, **as directed**.
   a. Color: As selected from manufacturer's full range.
5. Stainless-Steel Finish: Directional Satin No. 4.
6. Wood Finish: Unfinished **OR** Manufacturer's standard finish, **as directed**.

H. Fabrication
1. Metal Components: Form to required shapes and sizes with true, consistent curves, lines, and angles. Separate metals from dissimilar materials to prevent electrolytic action.
2. Welded Connections: Weld connections continuously. Weld solid members with full-length, full-penetration welds and hollow members with full-circumference welds. At exposed connections, finish surfaces smooth and blended so no roughness or unevenness shows after finishing and welded surface matches contours of adjoining surfaces.
3. Pipes and Tubes: Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cylindrical cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of handrail and railing components.
4. Preservative-Treated Wood Components: Complete fabrication of treated items before treatment if possible. If cut after treatment, apply field treatment complying with AWPA M4 to cut surfaces.
5. Exposed Surfaces: Polished, sanded, or otherwise finished; all surfaces smooth, free of burrs, barbs, splinters, and sharpness; all edges and ends rolled, rounded, or capped.
6. Factory Assembly: Assemble components in the factory to greatest extent possible to minimize field assembly. Clearly mark units for assembly in the field.

I. Finishes, General
1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

J. Aluminum Finishes
1. Baked-Enamel, Powder-Coat Finish: Manufacturer's standard, baked, polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

K. Steel And Galvanized Steel Finishes
1. Baked-Enamel, Powder-Coat Finish: Manufacturer's standard, baked, polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

2. PVC Finish: Manufacturer's standard, UV-light stabilized, mold-resistant, slip-resistant, matte-textured, dipped or sprayed-on, PVC-plastisol finish, with flame retardant added; complying with coating manufacturer's written instructions for pretreatment, application, and minimum dry film thickness.

L. Iron Finishes
1. Baked-Enamel, Powder-Coat Finish: Manufacturer's standard, baked, polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

M. Stainless-Steel Finishes
1. Remove tool and die marks and stretch lines or blend into finish.
2. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.

1.3 EXECUTION

A. Installation, General
1. Comply with manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of site furnishings where required.
2. Unless otherwise indicated, install site furnishings after landscaping and paving have been completed.
3. Install site furnishings level, plumb, true, and securely anchored **OR** positioned, **as directed**, at locations indicated on Drawings.
4. Post Setting: Set cast-in support posts in concrete footing with smooth top, shaped to shed water. Protect portion of posts above footing from concrete splatter. Verify that posts are set plumb or at correct angle and are aligned and at correct height and spacing. Hold posts in position during placement and finishing operations until concrete is sufficiently cured.
5. Posts Set into Voids in Concrete: Form or core-drill holes for installing posts in concrete to depth recommended in writing by manufacturer of site furnishings and 3/4 inch (19 mm) larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.
6. Pipe Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

B. Cleaning
1. After completing site furnishing installation, inspect components. Remove spots, dirt, and debris. Repair damaged finishes to match original finish or replace component.

END OF SECTION 32 33 23 00

Task	Specification	Specification Description
32 33 23 00	01 22 16 00	No Specification Required
32 33 23 00	32 33 13 00	Miscellaneous Site and Street Furnishings
32 33 33 00	32 33 23 00	Site Furnishings
32 33 33 00	32 33 13 00	Miscellaneous Site and Street Furnishings
32 33 43 13	32 33 23 00	Site Furnishings
32 33 43 53	32 33 13 00	Miscellaneous Site and Street Furnishings
32 33 53 00	01 22 16 00	No Specification Required
32 39 23 00	32 33 13 00	Miscellaneous Site and Street Furnishings
32 84 00 00	07 21 13 13	Modified Bitumous Protected Membrane Roofing

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SECTION 32 84 13 00 - IRRIGATION SYSTEMS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for irrigation systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Piping.
b. Encasement for piping.
c. Manual valves.
d. Pressure-reducing valves.
e. Automatic control valves.
f. Automatic drain valves.
g. Transition fittings.
h. Dielectric fittings.
i. Miscellaneous piping specialties.
j. Sprinklers.
k. Quick couplers.
l. Drip irrigation specialties.
m. Controllers.
n. Boxes for automatic control valves.

C. Definitions
1. Circuit Piping: Downstream from control valves to sprinklers, specialties, and drain valves. Piping is under pressure during flow.
2. Drain Piping: Downstream from circuit-piping drain valves. Piping is not under pressure.
3. Main Piping: Downstream from point of connection to water distribution piping to, and including, control valves. Piping is under water-distribution-system pressure.
4. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

D. Performance Requirements
1. Irrigation zone control shall be automatic operation with controller and automatic control **OR** manual operation with manual, **as directed**, valves.
2. Location of Sprinklers and Specialties: Design location is approximate. Make minor adjustments necessary to avoid plantings and obstructions such as signs and light standards. Maintain 100 percent irrigation coverage of areas indicated.
3. Delegated Design: Design 100 percent coverage irrigation system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
a. Available land records indicate the following soil conditions:
1) Type: Coarse **OR** Medium **OR** Fine, **as directed**.
2) Texture:
a) Sand: as directed by the Owner.
b) Silt: as directed by the Owner .
c) Clay: as directed by the Owner.
3) Particle Size:
a) Sand: as directed by the Owner.
b) Silt: as directed by the Owner.

c) Clay: as directed by the Owner.
4) Structure: Single grained **OR** Granular **OR** Platy **OR** Blocky, **as directed**.
5) Density: as directed by the Owner.
6) Moisture Content: as directed by the Owner.
7) Infiltration Rate: as directed by the Owner.

4. Minimum Working Pressures: The following are minimum pressure requirements for piping, valves, and specialties unless otherwise indicated:
   a. Irrigation Main Piping: 200 psig (1380 kPa).
   b. Circuit Piping: 150 psig (1035 kPa).

E. Submittals
1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Wiring Diagrams: For power, signal, and control wiring.
3. Delegated-Design Submittal: For irrigation systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
4. Zoning Chart: Show each irrigation zone and its control valve.
5. Controller Timing Schedule: Indicate timing settings for each automatic controller zone.
6. Field quality-control reports.
7. Operation and maintenance data.

F. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Delivery, Storage, And Handling
1. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.
2. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

H. Project Conditions
1. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
   a. Notify the Owner no fewer than two days in advance of proposed interruption of water service.
   b. Do not proceed with interruption of water service without the Owner's written permission.

1.2 PRODUCTS

A. Pipes, Tubes, And Fittings
1. Comply with requirements in the piping schedule for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.
2. Galvanized-Steel Pipe: ASTM A 53/A 53M, Standard Weight, Type E, Grade B.
   a. Galvanized-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106/A 106M, Standard Weight, seamless-steel pipe with threaded ends.
   b. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
   c. Malleable-Iron Unions: ASME B16.39, Class 150, hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface, and female threaded ends.
   d. Cast-Iron Flanges: ASME B16.1, Class 125.
3. Ductile-Iron Pipe with Mechanical Joints: AWWA C151, with mechanical-joint bell and spigot ends.

a. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
   1) Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

4. Ductile-Iron Pipe with Push-on Joint: AWWA C151, with push-on-joint bell and spigot ends.
   a. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
      1) Gaskets: AWWA C111, rubber.
5. Soft Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B), water tube, annealed temper.
   a. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper solder-joint fittings. Furnish wrought-copper fittings if indicated.
   b. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end.
   c. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.
6. Hard Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B), and ASTM B 88, Type M (ASTM B 88M, Type C), water tube, drawn temper.
   a. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper solder-joint fittings. Furnish wrought-copper fittings if indicated.
   b. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end.
   c. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.
7. PE Pipe with Controlled ID: ASTM F 771, PE 3408 compound; SIDR 11.5 and SIDR 15.
   a. Insert Fittings for PE Pipe: ASTM D 2609, nylon or propylene plastic with barbed ends. Include bands or other fasteners.
8. PE Pipe with Controlled OD: ASTM F 771, PE 3408 compound, SDR 11.
   a. PE Butt, Heat-Fusion Fittings: ASTM D 3261.
   b. PE Socket-Type Fittings: ASTM D 2683.
9. PE Pressure Pipe: AWWA C906, with DR of 7.3, 9, or 9.3 and PE compound number required to give pressure rating not less than 160 psig (1100 kPa) **OR** 200 psig (1380 kPa), **as directed**.
   a. PE Butt, Heat-Fusion Fittings: ASTM D 3261.
   b. PE Socket-Type Fittings: ASTM D 2683.
10. PVC Pipe: ASTM D 1785, PVC 1120 compound, Schedule 40 **OR** Schedule 80, **as directed**.
   a. PVC Socket Fittings: ASTM D 2466, Schedule 40 **OR** Schedule 80, **as directed**.
   b. PVC Threaded Fittings: ASTM D 2464, Schedule 80.
   c. PVC Socket Unions: Construction similar to MSS SP-107, except both headpiece and tailpiece shall be PVC with socket ends.
11. PVC Pipe, Pressure Rated: ASTM D 2241, PVC 1120 compound, SDR 21 and SDR 26.
   a. PVC Socket Fittings: ASTM D 2467, Schedule 80.
   b. PVC Socket Unions: Construction similar to MSS SP-107, except both headpiece and tailpiece shall be PVC with socket or threaded ends.

B. Piping Joining Materials
1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick unless otherwise indicated; full-face or ring type unless otherwise indicated.
2. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
3. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
4. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
5. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
6. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

C. Encasement For Piping
1. Standard: ASTM A 674 or AWWA C105.

2. Form: Sheet **OR** Tube, **as directed**.
3. Material: LLDPE film of 0.008-inch (0.20-mm) **OR** LLDPE film of 0.008-inch (0.20-mm) minimum thickness or high-density, cross-laminated PE film of 0.004-inch (0.10-mm) **OR** High-density, cross-laminated PE film of 0.004-inch (0.10-mm), **as directed**, minimum thickness.
4. Color: Black **OR** Natural, **as directed**.

D. Manual Valves
1. Curb Valves:
   a. Description:
      1) Standard: AWWA C800.
      2) NPS 1 (DN 25) and Smaller Pressure Rating: 100 psig (690 kPa) minimum **OR** 150 psig (1035 kPa), **as directed**.
      3) NPS 1-1/4 to NPS 2 (DN 32 to DN 50) Pressure Rating: 80 psig (550 kPa) minimum **OR** 150 psig (1035 kPa), **as directed**.
      4) Body Material: Brass or bronze with ball or ground-key plug.
      5) End Connections: Matching piping.
      6) Stem: With wide-tee head.
2. Curb-Valve Casing:
   a. Standard: Similar to AWWA M44 for cast-iron valve casings.
   b. Top Section: Telescoping, of length required for depth of burial of curb valve.
   c. Barrel: Approximately 3-inch (75-mm) diameter.
   d. Plug: With lettering "WATER."
   e. Bottom Section: With base of size to fit over valve.
   f. Base Support: Concrete collar **OR** wood frame, **as directed**.
3. Shutoff Rods for Curb-Valve Casings: Furnish one **OR** two, **as directed**, steel, tee-handle shutoff rod(s) with one pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve for Project.
4. Brass Ball Valves:
   a. Description:
      1) Standard: MSS SP-110.
      2) SWP Rating: 150 psig (1035 kPa).
      3) CWP Rating: 600 psig (4140 kPa).
      4) Body Design: Two piece.
      5) Body Material: Forged brass.
      6) Ends: Threaded or solder joint if indicated.
      7) Seats: PTFE or TFE.
      8) Stem: Brass.
      9) Ball: Chrome-plated brass.
      10) Port: Full **OR** regular, but not reduced, **as directed**.
5. Bronze Ball Valves:
   a. Description:
      1) Standard: MSS SP-110.
      2) SWP Rating: 150 psig (1035 kPa).
      3) CWP Rating: 600 psig (4140 kPa).
      4) Body Design: Two piece.
      5) Body Material: Bronze.
      6) Ends: Threaded or solder joint if indicated.
      7) Seats: PTFE or TFE.
      8) Stem: Bronze.
      9) Ball: Chrome-plated brass.
      10) Port: Full **OR** regular, but not reduced, **as directed**.
6. Iron Ball Valves:
   a. Description:
      1) Standard: MSS SP-72.
      2) CWP Rating: 200 psig (1380 kPa).

3) Body Design: Split body.
4) Body Material: ASTM A 126, gray iron.
5) Ends: Flanged.
6) Seats: PTFE or TFE.
7) Stem: Stainless steel.
8) Ball: Stainless steel.
9) Port: Full.

7. Plastic Ball Valves:
   a. Description:
      1) Standard: MSS SP-122.
      2) Pressure Rating: 125 psig (860 kPa) minimum **OR** 150 psig (1035 kPa), **as directed**.
      3) Body Material: PVC.
      4) Type: Union.
      5) End Connections: Socket or threaded.
      6) Port: Full.
8. Bronze Gate Valves:
   a. Description:
      1) Standard: MSS SP-80, Type 2.
      2) Class: 125.
      3) CWP Rating: 200 psig (1380 kPa).
      4) Body Material: ASTM B 62 bronze with integral seat and screw-in bonnet.
      5) Ends: Threaded or solder joint.
      6) Stem: Bronze, nonrising.
      7) Disc: Solid wedge; bronze.
      8) Packing: Asbestos free.
      9) Handwheel: Malleable iron, bronze, or aluminum.
9. Iron Gate Valves, Resilient Seated:
   a. Description:
      1) Standard: AWWA C509.
      2) Pressure Rating: 200 psig (1380 kPa) **OR** 250 psig (1725 kPa), **as directed**, minimum.
      3) Body Material: Ductile or gray iron with bronze trim.
      4) End Connections: Mechanical joint or push-on joint.
      5) Interior Coating: Comply with AWWA C550.
      6) Body Design: Nonrising stem.
      7) Operator: Stem nut.
      8) Disc: Solid wedge with resilient coating.
10. Iron Gate Valve Casings:
    a. Standard: AWWA M44 for cast-iron valve casings.
    b. Top Section: Adjustable extension of length required for depth of burial of valve.
    c. Barrel: Approximately 5-inch (125-mm) diameter.
    d. Plug: With lettering "WATER."
    e. Bottom Section: With base of size to fit over valve.
    f. Base Support: Concrete collar **OR** wood frame, **as directed**.
11. Operating Wrenches for Iron Gate Valve Casings: Furnish one **OR** two, **as directed**, steel, tee-handle operating wrench(es) with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut for Project.
12. Iron Gate Valves, NRS:
    a. Description:
       1) Standard: MSS SP-70, Type I.
       2) CWP Rating: 200 psig (1380 kPa).
       3) Body Material: ASTM A 126, gray iron with bolted bonnet.
       4) Ends: Flanged.
       5) Trim: All bronze.
       6) Disc: Solid wedge.

7) Packing and Gasket: Asbestos free.

13. Iron Gate Valves, OS&Y:
    a. Description:
        1) Standard: MSS SP-70, Type I.
        2) CWP Rating: 200 psig (1380 kPa).
        3) Body Material: ASTM A 126, gray iron with bolted bonnet.
        4) Ends: Flanged.
        5) Trim: All bronze.
        6) Disc: Solid wedge.
        7) Packing and Gasket: Asbestos free.

E. Pressure-Reducing Valves
1. Water Regulators:
    a. Description:
        1) Standard: ASSE 1003.
        2) Body Material: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).
        3) Pressure Rating: Initial pressure of 150 psig (1035 kPa).
        4) End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).
2. Water Control Valves:
    a. Description: Pilot-operation, diaphragm-type, single-seated main water control valve. Include small pilot control valve, restrictor device, specialty fittings, and sensor piping.
        1) Main Valve Body: Cast- or ductile-iron body with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body.
        2) Pattern: Angle-valve **OR** Globe-valve, **as directed**, design.
        3) Trim: Stainless steel.
        4) Pressure Rating: Initial pressure of 150 psig (1035 kPa) minimum.
        5) End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.

F. Automatic Control Valves
1. Bronze, Automatic Control Valves:
    a. Description: Cast-bronze body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid.
2. Plastic, Automatic Control Valves:
    a. Description: Molded-plastic body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid.

G. Automatic Drain Valves
1. Description: Spring-loaded-ball type of corrosion-resistant construction and designed to open for drainage if line pressure drops below 2-1/2 to 3 psig (17 to 20 kPa).

H. Transition Fittings
1. General Requirements: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
2. Transition Couplings:
    a. Description: AWWA C219, metal sleeve-type coupling for underground pressure piping.
3. Plastic-to-Metal Transition Fittings:
    a. Description: PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-socket or threaded end.
4. Plastic-to-Metal Transition Unions:

a. Description: MSS SP-107, PVC four-part union. Include one brass or stainless-steel threaded end, one solvent-cement-joint or threaded plastic end, rubber O-ring, and union nut.

I. Dielectric Fittings
1. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.
2. Dielectric Unions:
a. Description: Factory-fabricated union, NPS 2 (DN 50) and smaller.
1) Pressure Rating: 150 psig (1035 kPa) minimum **OR** 250 psig (1725 kPa), **as directed**, at 180 deg F (82 deg C).
2) End Connections: Solder-joint copper alloy and threaded ferrous; threaded ferrous.
3. Dielectric Flanges:
a. Description: Factory-fabricated, bolted, companion-flange assembly, NPS 2-1/2 to NPS 4 (DN 65 to DN 100) and larger.
1) Pressure Rating: 150 psig (1035 kPa) minimum **OR** 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
2) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
4. Dielectric-Flange Kits:
a. Description: Nonconducting materials for field assembly of companion flanges, NPS 2-1/2 (DN 65) and larger.
1) Pressure Rating: 150 psig (1035 kPa) minimum.
2) Gasket: Neoprene or phenolic.
3) Bolt Sleeves: Phenolic or polyethylene.
4) Washers: Phenolic with steel backing washers.
5. Dielectric Couplings:
a. Description: Galvanized-steel coupling.
1) Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
2) End Connections: Female threaded.
3) Lining: Inert and noncorrosive, thermoplastic lining.
6. Dielectric Nipples:
a. Description: Electroplated steel nipple complying with ASTM F 1545.
1) Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
2) End Connections: Male threaded or grooved.
3) Lining: Inert and noncorrosive, propylene.

J. Miscellaneous Piping Specialties
1. Water Hammer Arresters: ASSE 1010 or PDI WH 201, with bellows or piston-type pressurized cushioning chamber and in sizes complying with PDI WH 201, Sizes A to F.
2. Pressure Gages: ASME B40.1. Include 4-1/2-inch- (115-mm-) diameter dial, dial range of two times system operating pressure, and bottom outlet.

K. Sprinklers
1. General Requirements: Designed for uniform coverage over entire spray area indicated at available water pressure.
2. Metal, Exposed, Impact-Drive Rotary Sprinklers:
a. Description:
1) Construction: Brass and other corrosion-resistant metals.
2) Mounting: Aboveground, exposed on riser.
3. Plastic, Exposed, Impact-Drive Rotary Sprinklers:
a. Description:
1) Construction: ABS and corrosion-resistant metals.
2) Mounting: Aboveground, exposed on riser.
4. Plastic, Pop-up, Gear-Drive Rotary Sprinklers:

a. Description:
1) Body Material: ABS.
2) Nozzle: ABS **OR** Brass, **as directed**.
3) Retraction Spring: Stainless steel.
4) Internal Parts: Corrosion resistant.

5. Metal, Pop-up, Impact-Drive Rotary Sprinklers:
a. Description:
1) Case: Brass.
2) Body Material: Brass.
3) Pop-up Height: Approximately 3 inches (75 mm).
4) Sprinkler Construction: Brass and other corrosion-resistant metals.

6. Plastic, Pop-up, Impact-Drive Rotary Sprinklers:
a. Description:
1) Case: ABS.
2) Pop-up Height: Approximately 3 inches (75 mm).
3) Sprinkler Construction: ABS and other corrosion-resistant metals.

7. Metal, Surface Spray Sprinklers:
a. Description:
1) Body Material and Flange: Brass.
2) Nozzle: Brass.
3) Pattern: Fixed, with flow adjustment.

8. Plastic, Surface Spray Sprinklers:
a. Description:
1) Body Material and Flange: ABS.
2) Pattern: Fixed, with flow adjustment.

9. Metal, Surface, Pop-up Spray Sprinklers:
a. Description:
1) Body Material and Flange: Brass.
2) Nozzle: Brass.
3) Pattern: Fixed, with flow adjustment.

10. Plastic, Surface, Pop-up Spray Sprinklers:
a. Description:
1) Body Material and Flange: ABS.
2) Pattern: Fixed, with flow adjustment.

11. Plastic, Pop-up Spray Sprinklers:
a. Description:
1) Body Material: ABS.
2) Nozzle: ABS **OR** Brass, **as directed**.
3) Retraction Spring: Stainless steel.
4) Internal Parts: Corrosion resistant.
5) Pattern: Fixed, with flow adjustment.

12. Metal Shrub Sprinklers:
a. Description:
1) Body Material: Brass.
2) Nozzle: Brass.
3) Pattern: Fixed, with flow adjustment.

13. Plastic Shrub Sprinklers:
a. Description:
1) Body Material: ABS or other plastic.
2) Pattern: Fixed, with flow adjustment.

L. Quick Couplers
1. Description: Factory-fabricated, bronze or brass, two-piece assembly. Include coupler water-seal valve; removable upper body with spring-loaded or weighted, rubber-covered cap; hose swivel with ASME B1.20.7, 3/4-11.5NH threads for garden hose on outlet; and operating key.

a. Locking-Top Option: Vandal-resistant locking feature. Include one **OR** two, **as directed**, matching key(s).

M. Drip Irrigation Specialties
1. Freestanding Emitters: Device to deliver water at approximately 20 psig (138 kPa).
   a. Body Material: PE or vinyl, with flow control.
   b. Riser to Emitter: PE or PVC flexible tubing.
2. Manifold Emitter Systems: Manifold with tubing and emitters.
   a. Manifold: With multiple outlets to deliver water to emitters.
      1) Body Material: Plastic.
      2) Outlet Caps: Plastic, for outlets without installed tubing.
      3) Operation: Automatic pressure compensating.
   b. Tubing: PE or PVC; 1/8-inch (3-mm) minimum ID.
   c. Emitter: Device to deliver water at approximately 20 psig (138 kPa).
      1) Body Material: PE or vinyl, with flow control.
3. Multiple-Outlet Emitter Systems: Emitter with tubing and button-type outlets.
   a. Emitter: With multiple outlets to deliver water to remote outlets.
      1) Body Material: Plastic, with flow control.
      2) Outlet Caps: Plastic, for outlets without installed tubing.
      3) Operation: Automatic pressure compensating.
      4) Emitters: Devices to deliver water at approximately 20 psig (138 kPa).
   b. Tubing: PE or PVC; 1/8-inch (3-mm) minimum ID.
4. Drip Tubes with Direct-Attached Emitters:
   a. Tubing: Flexible PE or PVC with plugged end.
   b. Emitters: Devices to deliver water at approximately 20 psig (138 kPa).
      1) Body Material: PE or vinyl, with flow control.
      2) Mounting: Inserted into tubing at set intervals.
5. Drip Tubes with Remote Discharge:
   a. Tubing: Flexible PE or PVC with plugged end.
   b. Emitters: Devices to deliver water at approximately 20 psig (138 kPa).
      1) Body Material: PE or vinyl, with flow control.
      2) Mounting: Inserted into tubing at set intervals.
6. Off-Ground Supports: Plastic stakes.
7. Application Pressure Regulators: Brass or plastic housing, NPS 3/4 (DN 20), with corrosion-resistant internal parts; capable of controlling outlet pressure to approximately 20 psig (138 kPa).
8. Filter Units: Brass or plastic housing, with corrosion-resistant internal parts; of size and capacity required for devices downstream from unit.
9. Air Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.
10. Vacuum Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.

N. Controllers
1. Description:
   a. Controller Stations for Automatic Control Valves: Each station is variable from approximately 5 to 60 minutes. Include switch for manual or automatic operation of each station.
   b. Exterior Control Enclosures: NEMA 250, Type 4, weatherproof, with locking cover and two matching keys; include provision for grounding.
      1) Body Material: Enameled-steel sheet metal **OR** Stainless-steel sheet metal **OR** Molded plastic, **as directed**.
      2) Mounting: Freestanding type for concrete base **OR** Surface type for wall, **as directed**.
   c. Interior Control Enclosures: NEMA 250, Type 12, dripproof, with locking cover and two matching keys.
      1) Body Material: Enameled-steel sheet metal **OR** Stainless-steel sheet metal **OR** Molded plastic, **as directed**.

2) Mounting: Freestanding type for concrete base **OR** Surface type for wall, **as directed**.

d. Control Transformer: 24-V secondary, with primary fuse.

e. Timing Device: Adjustable, 24-hour, 14-day clock, with automatic operations to skip operation any day in timer period, to operate every other day, or to operate two or more times daily.

1) Manual or Semiautomatic Operation: Allows this mode without disturbing preset automatic operation.

2) Nickel-Cadmium Battery and Trickle Charger: Automatically powers timing device during power outages.

3) Surge Protection: Metal-oxide-varistor type on each station and primary power.

f. Moisture Sensor: Adjustable from one to seven days, to shut off water flow during rain.

g. Wiring: UL 493, Type UF multiconductor, with solid-copper conductors; insulated cable; suitable for direct burial.

1) Feeder-Circuit Cables: No. 12 AWG minimum, between building and controllers.

2) Low-Voltage, Branch-Circuit Cables: No. 14 AWG minimum, between controllers and automatic control valves; color-coded different from feeder-circuit-cable jacket color; with jackets of different colors for multiple-cable installation in same trench.

3) Splicing Materials: Manufacturer's packaged kit consisting of insulating, spring-type connector or crimped joint and epoxy resin moisture seal; suitable for direct burial.

h. Concrete Base: Reinforced precast concrete not less than 36 by 24 by 4 inches (900 by 600 by 100 mm) thick, and 6 inches (150 mm) greater in each direction than overall dimensions of controller. Include opening for wiring.

O. Boxes For Automatic Control Valves

1. Plastic Boxes:

a. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.

1) Size: As required for valves and service.

2) Shape: Round **OR** Square **OR** Rectangular, **as directed**.

3) Sidewall Material: PE **OR** PE, ABS, or FRP, **as directed**.

4) Cover Material: PE **OR** PE, ABS, or FRP, **as directed**.

a) Lettering: "VALVE BOX" **OR** "IRRIGATION," **as directed**.

2. Polymer-Concrete Boxes:

a. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.

1) Size: As required for valves and service.

2) Shape: Round **OR** Square **OR** Rectangular, **as directed**.

3) Sidewall Material: Polymer concrete with lateral and vertical sidewall design loading of 5000 lb (2268 kg) **OR** 10,000 lb (4536 kg) **OR** 15,000 lb (6800 kg), **as directed**, minimum over 10 by 10 inches (254 by 254 mm) square.

4) Cover Material: Polymer concrete **OR** Reinforced polymer concrete, **as directed**, with cover design loading of 5000 lb (2268 kg) **OR** 10,000 lb (4536 kg) **OR** 15,000 lb (6800 kg), **as directed**, minimum over 10 by 10 inches (254 by 254 mm) square.

a) Lettering: "VALVE BOX" **OR** "IRRIGATION," **as directed**.

3. Drainage Backfill: Cleaned gravel or crushed stone, graded from 3/4 inch (19 mm) minimum to 3 inches (75 mm) maximum.

1.3 EXECUTION

A. Earthwork

1. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving".
2. Install warning tape directly above pressure piping, 12 inches (300 mm) below finished grades, except 6 inches (150 mm) below subgrade under pavement and slabs.

3. Drain Pockets: Excavate to sizes indicated. Backfill with cleaned gravel or crushed stone, graded from 3/4 to 3 inches (19 to 75 mm), to 12 inches (300 mm) below grade. Cover gravel or crushed stone with sheet of asphalt-saturated felt and backfill remainder with excavated material.
4. Provide minimum cover over top of underground piping according to the following:
   a. Irrigation Main Piping: Minimum depth of 36 inches (900 mm) below finished grade, or not less than 18 inches (450 mm) below average local frost depth, whichever is deeper.
   b. Circuit Piping: 12 inches (300 mm).
   c. Drain Piping: 12 inches (300 mm)
   d. Sleeves: 24 inches (600 mm).

B. Piping Installation
1. Location and Arrangement: Drawings indicate location and arrangement of piping systems. Install piping as indicated unless deviations are approved on Coordination Drawings.
2. Install piping at minimum uniform slope of 0.5 percent down toward drain valves.
3. Install piping free of sags and bends.
4. Install groups of pipes parallel to each other, spaced to permit valve servicing.
5. Install fittings for changes in direction and branch connections.
6. Install unions adjacent to valves and to final connections to other components with NPS 2 (DN 50) or smaller pipe connection.
7. Install flanges adjacent to valves and to final connections to other components with NPS 2-1/2 (DN 65) or larger pipe connection.
8. Install underground thermoplastic piping according to ASTM D 2774 and ASTM F 690.
9. Install expansion loops in control-valve boxes for plastic piping.
10. Lay piping on solid subbase, uniformly sloped without humps or depressions.
11. Install ductile-iron piping according to AWWA C600.
12. Install PVC piping in dry weather when temperature is above 40 deg F (5 deg C). Allow joints to cure at least 24 hours at temperatures above 40 deg F (5 deg C) before testing.
13. Install water regulators with shutoff valve and strainer on inlet and pressure gage on outlet. Install shutoff valve on outlet. Install aboveground or in control-valve boxes.
14. Water Hammer Arresters: Install between connection to building main and circuit valves aboveground or in control-valve boxes.
15. Install piping in sleeves under parking lots, roadways, and sidewalks.
16. Install sleeves made of Schedule 40 **OR** Schedule 80, **as directed**, PVC pipe and socket fittings, and solvent-cemented joints.
17. Install transition fittings for plastic-to-metal pipe connections according to the following:
   a. Underground Piping:
      1) NPS 1-1/2 (DN 40) and Smaller: Plastic-to-metal transition fittings.
      2) NPS 2 (DN 50) and Larger: AWWA transition couplings.
   b. Aboveground Piping:
      1) NPS 2 (DN 50) and Smaller: Plastic-to-metal transition fittings **OR** unions, **as directed**.
      2) NPS 2 (DN 50) and Larger: Use dielectric flange kits with one plastic flange.
18. Install dielectric fittings for dissimilar-metal pipe connections according to the following:
   a. Underground Piping:
      1) NPS 2 (DN 50) and Smaller: Dielectric coupling or dielectric nipple.
      2) NPS 2-1/2 (DN 65) and Larger: Prohibited except in control-valve box.
   b. Aboveground Piping:
      1) NPS 2 (DN 50) and Smaller: Dielectric union.
      2) NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Dielectric flange.
      3) NPS 5 (DN 125) and Larger: Dielectric flange kit.
   c. Piping in Control-Valve Boxes:
      1) NPS 2 (DN 50) and Smaller: Dielectric union.
      2) NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Dielectric flange.
      3) NPS 5 (DN 125) and Larger: Dielectric flange kit.

C. Joint Construction

1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
3. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
4. Flanged Joints: Select rubber gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
5. Ductile-Iron Piping Gasketed Joints: Comply with AWWA C600 and AWWA M41.
6. Copper-Tubing Brazed Joints: Construct joints according to CDA's "Copper Tube Handbook," using copper-phosphorus brazing filler metal.
7. Copper-Tubing Soldered Joints: Apply ASTM B 813 water-flushable flux to tube end unless otherwise indicated. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy (0.20 percent maximum lead content) complying with ASTM B 32.
8. PE Piping Fastener Joints: Join with insert fittings and bands or fasteners according to piping manufacturer's written instructions.
9. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
   a. Plain-End PE Pipe and Fittings: Use butt fusion.
   b. Plain-End PE Pipe and Socket Fittings: Use socket fusion.
10. PVC Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
    a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
    b. PVC Pressure Piping: Join schedule number, ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
    c. PVC Nonpressure Piping: Join according to ASTM D 2855.

D. Valve Installation
1. Underground Curb Valves: Install in curb-valve casings with tops flush with grade.
2. Underground Iron Gate Valves, Resilient Seat: Comply with AWWA C600 and AWWA M44. Install in valve casing with top flush with grade.
   a. Install valves and PVC pipe with restrained, gasketed joints.
3. Aboveground Valves: Install as components of connected piping system.
4. Pressure-Reducing Valves: Install in boxes for automatic control valves or aboveground between shutoff valves. Install full-size valved bypass, **as directed**.
5. Throttling Valves: Install in underground piping in boxes for automatic control valves.
6. Drain Valves: Install in underground piping in boxes for automatic control valves.

E. Sprinkler Installation
1. Install sprinklers after hydrostatic test is completed.
2. Install sprinklers at manufacturer's recommended heights.
3. Locate part-circle sprinklers to maintain a minimum distance of 4 inches (100 mm) from walls and 2 inches (50 mm) from other boundaries unless otherwise indicated.

F. Drip Irrigation Specialty Installation
1. Install freestanding emitters on pipe riser to mounting height indicated.
2. Install manifold emitter systems with tubing to emitters. Plug unused manifold outlets. Install emitters on off-ground supports at height indicated.

3. Install multiple-outlet emitter systems with tubing to outlets. Plug unused emitter outlets. Install outlets on off-ground supports at height indicated.
4. Install drip tubes with direct-attached emitters on ground.
5. Install drip tubes with remote-discharge on ground with outlets on off-ground supports at height indicated.
6. Install off-ground supports of length required for indicated mounted height of device.
7. Install application pressure regulators and filter units in piping near device being protected, and aboveground **OR** in control-valve boxes, **as directed**.
8. Install air relief valves and vacuum relief valves in piping, and aboveground **OR** in control-valve boxes, **as directed**.

G. Automatic Irrigation-Control System Installation
1. Equipment Mounting: Install interior controllers on floor **OR** concrete bases **OR** wall, **as directed**.
   a. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   b. Install anchor bolts to elevations required for proper attachment to supported equipment.
2. Equipment Mounting: Install exterior freestanding controllers on precast concrete bases.
   a. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   b. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install control cable in same trench as irrigation piping and at least 2 inches (51 mm) below or beside piping. Provide conductors of size not smaller than recommended by controller manufacturer. Install cable in separate sleeve under paved areas.

H. Connections
1. Comply with requirements for piping specified in Division 22 Section "Facility Water Distribution Piping" for water supply from exterior water service piping, water meters, protective enclosures, and backflow preventers. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to equipment, valves, and devices to allow service and maintenance.
3. Connect wiring between controllers and automatic control valves.

I. Identification
1. Identify system components. Comply with requirements for identification specified in Division 22 Section "Identification For Plumbing Piping And Equipment".
2. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on each automatic controller.
   a. Text: In addition to identifying unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
3. Warning Tapes: Arrange for installation of continuous, underground, detectable warning tapes over underground piping during backfilling of trenches. See Division 31 Section "Earth Moving" for warning tapes.

J. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
   a. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   b. Operational Test: After electrical circuitry has been energized, operate controllers and automatic control valves to confirm proper system operation.
   c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Any irrigation product will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

K. Adjusting
1. Adjust settings of controllers.
2. Adjust automatic control valves to provide flow rate at rated operating pressure required for each sprinkler circuit.
3. Adjust sprinklers and devices, except those intended to be mounted aboveground, so they will be flush with, or not more than 1/2 inch (13 mm) above, finish grade.

L. Cleaning
1. Flush dirt and debris from piping before installing sprinklers and other devices.

M. Piping Schedule
1. Install components having pressure rating equal to or greater than system operating pressure.
2. Piping in control-valve boxes and aboveground may be joined with flanges or unions instead of joints indicated.
3. Aboveground irrigation main piping, NPS 4 (DN 100) and smaller, shall be one of the following:
   a. Galvanized-steel pipe and galvanized-steel pipe nipples; galvanized, gray-iron threaded fittings; and threaded joints.
   b. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube, wrought- or cast-copper fittings, and brazed **OR** soldered, **as directed**, joints.
   c. Schedule 40 **OR** Schedule 80, **as directed**, PVC pipe; socket-type PVC fittings; and solvent-cemented joints.
   d. Schedule 80, PVC pipe; Schedule 80, threaded PVC fittings; and threaded joints.
4. Aboveground irrigation main piping, NPS 5 (DN 125) and larger, shall be one of the following:
   a. Galvanized-steel pipe and galvanized-steel pipe nipples; galvanized, gray-iron threaded fittings; and threaded joints.
   b. Schedule 40 **OR** Schedule 80, **as directed**, PVC pipe and socket fittings; and solvent-cemented joints.
   c. Schedule 80, PVC pipe; Schedule 80, threaded PVC fittings; and threaded joints.
5. Underground irrigation main piping, NPS 4 (DN 100) and smaller, shall be one of the following:
   a. NPS 3 and NPS 4 (DN 80 and DN 100) ductile-iron, mechanical-joint pipe; ductile-iron, mechanical-joint fittings, glands, bolts, and nuts; and gasketed joints.
   b. NPS 3 and NPS 4 (DN 80 and DN 100) ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings and gaskets; and gasketed joints.
   c. Type L (Type B) soft copper tube, wrought-copper fittings, and brazed joints.
   d. NPS 4 (DN 100) PE pressure pipe; PE butt, heat-fusion or socket-type fittings; and heat-fusion joints.
   e. Schedule 40 **OR** Schedule 80, **as directed**, PVC pipe and socket fittings, and solvent-cemented joints.
   f. Schedule 80, PVC pipe; Schedule 80, threaded PVC fittings; and threaded joints.
   g. SDR 21, PVC, pressure-rated pipe; Schedule 80, PVC socket fittings; and solvent-cemented joints.
6. Underground irrigation main piping, NPS 5 (DN 125) and larger, shall be one of the following:
   a. NPS 6 (DN 150) and larger ductile-iron, mechanical-joint pipe; ductile-iron, mechanical-joint fittings, glands, bolts, and nuts; and gasketed joints.
   b. NPS 6 (DN 150) and larger ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings and gaskets; and gasketed joints.
   c. PE pressure pipe; PE butt, heat-fusion fittings; and heat-fusion joints.
   d. Schedule 40 **OR** Schedule 80, **as directed**, PVC pipe and socket fittings; and solvent-cemented joints.
   e. SDR 21, PVC, pressure-rated pipe; Schedule 80, PVC socket fittings; and solvent-cemented joints.
7. Circuit piping, NPS 2 (DN 50) and smaller, shall be one of the following:
   a. SIDR 7 **OR** SIDR 9, **as directed**, PE, controlled ID pipe; insert fittings for PE pipe; and fastener joints.

b. DR 9 **OR** DR 11, **as directed**, PE, controlled OD pipe; PE butt, heat-fusion, or PE socket-type fittings; and heat-fusion joints.
c. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
d. SDR 26, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.

8. Circuit piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100), shall be one of the following:
   a. SIDR 7 **OR** SIDR 9, **as directed**, PE, controlled ID pipe; insert fittings for PE pipe; and banded or fastener joints.
   b. DR 9 **OR** DR 11, **as directed**, PE, controlled OD pipe; PE socket or butt-fusion fittings; and heat-fusion joints. NPS 3 (DN 80) pipe and fittings if NPS 2-1/2 (DN 65) pipe and fittings are not available.
   c. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
   d. SDR 26, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.
9. Underground Branches and Offsets at Sprinklers and Devices: Schedule 80, PVC pipe; threaded PVC fittings; and threaded joints.
   a. Option: Plastic swing-joint assemblies, with offsets for flexible joints, manufactured for this application.
10. Risers to Aboveground Sprinklers and Specialties: Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube, wrought-copper fittings, and brazed **OR** soldered, **as directed**, joints.
11. Risers to Aboveground Sprinklers and Specialties: Schedule 80, PVC pipe and socket fittings; and solvent-cemented joints.
12. Drain piping shall be one of the following:
    a. SIDR 9, 11.5, or 15, PE, controlled ID pipe; insert fittings for PE pipe; and banded or fastener joints.
    b. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
    c. SDR 21, 26, or 32.5, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.

N. Valve Schedule
1. Underground, Shutoff-Duty Valves: Use the following:
   a. NPS 2 (DN 50) and Smaller: Curb valve, curb-valve casing, and shutoff rod.
   b. NPS 3 (DN 80) and Larger: Iron gate valve, resilient seated; iron gate valve casing; and operating wrench(es).
2. Aboveground, Shutoff-Duty Valves:
   a. NPS 2 (DN 50) and Smaller: Brass **OR** Bronze **OR** Plastic, **as directed**, ball valve.
   b. NPS 2 (DN 50) and Smaller: Bronze gate valve.
   c. NPS 2-1/2 (DN 65) and Larger: Iron ball valve.
   d. NPS 2-1/2 (DN 65) and Larger: Iron gate valve, NRS **OR** OS&Y, **as directed**.
3. Throttling-Duty Valves:
   a. NPS 2 (DN 50) and Smaller: Bronze **OR** Plastic, **as directed**, automatic control valve.
   b. NPS 2 (DN 50) and Smaller: Brass **OR** Bronze **OR** Plastic, **as directed**, ball valve.
   c. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): Bronze **OR** Plastic, **as directed**, automatic control valve.
   d. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): Iron ball valve.
4. Drain Valves:
   a. NPS 1/2 and NPS 3/4 (DN 15 and DN 20): Automatic drain valve.
   b. NPS 1/2 and NPS 3/4 (DN 15 and DN 20): Brass **OR** Bronze **OR** Plastic, **as directed**, ball valve.
   c. NPS 1/2 and NPS 3/4 (DN 15 and DN 20): Bronze gate valve.
   d. NPS 1 to NPS 2 (DN 25 to DN 50): Brass **OR** Bronze **OR** Plastic, **as directed**, ball valve.
   e. NPS 1 to NPS 2 (DN 25 to DN 50): Bronze gate valve.

END OF SECTION 32 84 13 00

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Task	Specification	Specification Description
32 84 13 00	07 21 13 13	Modified Bitumous Protected Membrane Roofing
32 84 23 00	01 22 16 00	No Specification Required
32 84 23 00	32 84 13 00	Irrigation Systems
32 84 23 00	03 05 13 00	Cast-In-Place Concrete
32 84 23 00	07 21 13 13	Modified Bitumous Protected Membrane Roofing
32 84 23 00	07 63 00 00	Common Work Results for Fire Suppression
32 84 23 00	07 63 00 00a	Common Work Results for Plumbing
32 84 23 00	07 63 00 00b	Common Work Results for HVAC

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SECTION 32 91 13 16 - TREE RELOCATION

1.1 GENERAL

A. Description Of Work
1. This specification covers labor, materials, necessary equipment and services to complete the tree relocation work. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.
2. Before tree excavation, pruning, removal, or relocation of existing trees, contractor shall notify:
   a. the Owner of schedule of operation.
   b. Appropriate utility companies and the Owner for flagging and coordination of service disconnection as necessary to complete work.
   c. Coordinate work with other trades.

B. Definitions
1. Toxic Substances: Do not deliver any toxic substance or item as defined by the state, to the site without furnishing to the Owner a Material Safety Data Sheet (MSDS). Provide current MSDS information with each initial shipment.
   a. The MSDS shall contain the following information:
      1) The chemical name and the common name of the toxic substance.
      2) The hazards or other risks in the use of the toxic substance, including:
         a) The potential for fire, explosion, corrosivity and reactivity.
         b) The known acute and chronic health effects of risks from exposure, including the medical conditions which are generally recognized as being aggravated by exposure to the toxic substance.
         c) The primary routes of entry and symptoms of overexposure.
      3) The proper precautions, handling practices, necessary personal protective equipment, any other safety precautions in the use of or exposure to the toxic substance including appropriate emergency treatment in case of overexposure.
      4) The emergency procedure for spills, fire disposal, and first aid.
      5) A description in lay terms of the known specific potential health risks posed by the toxic substance intended to alert any person reading this information.
      6) The year and month, if available, that the information was compiled and the name, address, and emergency telephone number of the manufacturer responsible for preparing the information.

C. Description
1. Protect existing trees to remain during construction phases. Provide tree protection barriers for those existing trees adjacent to tree transplantation operations. Any trees scarred or destroyed, designated to remain, will be replaced at the Contractor's expense, with similar species, size, and quality.
2. Remove other vegetation as necessary and as required to meet project requirements to accommodate new plantings. Prepare areas to be planted according to Division 32 Section "Plants".
3. Resulting tree pits of relocated material shall be backfilled with clean fill and brought back flush with surrounding grade, unless the pits are to be immediately replanted. Stabilize grade if required. Correct problems caused by erosion, wind, etc., in the reclaimed area. Pits to be quickly replanted shall be surrounded by safety barricades to prevent accidental falls into pits.
   a. In areas where new plant material will replace relocated plant material, appropriate planting soil mix shall be used as backfill.

D. Submittals

1. Submit a list of equipment, procedure, and labor force anticipated for use for tree relocation for approval by the Owner.
2. Submit a schedule by day indicating units to be dug and relocated. Note materials requiring root pruning, and that the relocation schedule is to begin at the end of the specified root pruning period.
3. Obtain permits required by authority having jurisdiction.
4. Submit written certification that trees indicated to remain have been protected during the course of construction according to recognized standards of the industry. Certify that where damage did occur:
   a. Trees were promptly and properly treated.
   b. Indicate which damaged trees (if any) are incapable of retaining full growth potential and are recommended to be replaced.
5. Submit for approval, proposed methods, and schedule for effecting tree and plant protection.

E. Quality Assurance
1. Unless otherwise specified, tree transplanting shall comply with NAA Ref.1.
2. Comply with NAA standards for pruning and remove branches from trees to remain to clear new construction.
3. Recommend procedures to compensate for loss of roots (if any) and perform initial pruning of branches and stimulation of root growth where removed to accommodate new construction.
4. Perform tree repair work for damage incurred by new construction.
5. Provide routine progress evaluation reports on relocated trees until the end of the maintenance period.
6. Evaluate existing trees and verify trees are free of disease and ready to survive relocation from the site to their new location on-site or off-site.

F. Delivery, Storage, and Handling
1. Properly handle trees and palms during moving so trunks will not be scarred or damaged and to avoid broken limbs. Broken limbs not causing the tree to be rejected shall be repaired as follows:
   a. Properly prune dead, dying, or damaged branches with clean, sharp equipment.
   b. Remove injured bark and wood of a tree would with a clean, sharp knife to a point where healthy bark and wood make contact at their margins.
   c. Inspect and treat wound for insect and disease.
   d. Seal wounds with bituminous base wound paint for all oak limbs greater than 3 inch diameter.
2. Transport trees on vehicles of adequate size to prevent overcrowding, broken limbs, foliage damage, or root ball damage.
3. Keep root balls moist during relocation.
4. Protect tree crowns with shade cloth to prevent desiccation and wind burn. Crowns shall be periodically sprayed with water to help ensure against desiccation.
5. Handle plant material only in ways and means accepted by the landscaping industry and accepted by the Owner.
6. Plant material shall be planted the same day it is dug. Coordinate preparation of planting pits or beds to ensure this schedule.

G. Warranty
1. Relocated plant material does not fall under the standard 12 month guarantee.
2. For relocated trees or palms that die, replace their canopy area with new trees as specified.
   a. Canopy spread for all palms and trees shall be listed on proposal when submitted for relocation work.
   b. Replacements (mitigation plantings) shall be provided at no additional cost to the Owner.
   c. Submit the attached form to the Owner for review and approval.
   d. Proposed replacement canopy tree species shall be the Owner accepted trees and palms.
3. Repair damage to other plants and lawn or construction work within the relocation area during tree transplantation at no cost to the Owner. This includes, but is not limited to, damage to curbs,

walks, roads, fences, site furnishings, etc. Replacing and replanting of damaged trees or shrubs shall be according to Division 32 Section "Plants" Replacing and replanting of damaged turf shall be according to Division 32 Section "Turf And Grasses".

H. Maintenance
1. Maintain relocated plant materials immediately after each item is planted and continued until the 90 day watering period is completed, upon which time the Owner will take over maintenance of materials following procedures and recommendations of contractor and specifications.
2. During the maintenance period, maintain relocated plant materials.

1.2 PRODUCT

A. Materials
1. Bone meal shall be readily available steamed bone meal, useable as a natural organic nitrogen fertilizer.
2. Peat moss, topsoil, planting soil, mulch, staking, and guying shall be as specified in Division 32 Section "Plants".

1.3 EXECUTION

A. Transplantation
1. Transplanting shall consist of on-site or off-site transplanting of existing trees or palms from proposed construction areas to permanent positions.
2. Digging, Wrapping, and Handling: Plants shall be dug and prepared for moving in a manner that will not cause damage to branches, shape, root system, and development.
3. Balled and Burlapped Plants:
   a. Balls shall be firmly wrapped with burlap or accepted cloth substitute.
   b. No balled plant will be acceptable if the ball is cracked and broken or if the stem or trunk is loose in the ball, either before or during transplanting.
   c. Balled plants shall be lifted and handled from the bottom of the ball.
   d. Protect ball and deliver to the site, plant immediately, and water thoroughly.
   e. Ball sizes shall be as recommended in ANSI Z 60.1.

B. Planting
1. Relocated Material
   a. Relocated trees/palms shall be planted according to procedures described for new material, Division 32 Section "Plants". Verify final grades have been established before planting operations. Ensure proposed planting pits drain by test-filling with water before transplantation.
   b. Continue watering and caring for relocated material as specified.
   c. Mulch tree pit areas to reduce weeds, discourage foot traffic, conserve moisture, and minimize temperature fluctuations.
   d. Brace trunk and leave in place for approximately one year until trees are wind firm.
   e. Wrap trunks and structural branches of thin-barked trees to protect against sun scald and dehydration. Retain through at least one growing season, and through cold season.
   f. Feed with a diluted solution of N-P-K in solution form with a soil needle, providing water, air, and nutrients.
   g. Where foliage is retarded, spray with one of the soluble types of foliage feeders.
   h. At time of planting, fill air pockets and keep roots, especially feeder roots, moist, live, and healthy. Use soil needles for watering new transplants. Direct fine spray at foliage to help harden-off new leaves.

C. Staking And Guying: Stake and guy designated material according to procedures described for new plant materials, Division 32 Section "Plants".

D. Watering
1. Following transplantation, water trees daily for the first two weeks, every other day for the next three weeks, and every third day for the balance of the three month watering/maintenance period. Such watering shall thoroughly saturate the root ball to its full depth.
2. Following relocation, trees designated for transplanting shall be watered as specified in this section. Such watering shall thoroughly saturate the root ball to its full depth.
3. Provide manual watering of relocated plant materials for 90 days. If used, after watering period, Contractor shall be responsible for the complete removal of all temporary watering systems.

E. Tagging: Trees within the designated areas for relocation shall be clearly marked by means of yellow plastic surveyor's ribbons and coordinated with, inspected, and accepted by the Owner before root pruning and digging.

F. Root Preparation
1. Trees to be relocated shall be root pruned at least 45 days before digging with clean, sharp equipment.
   a. Maintain root pruned materials by watering, weeding, mowing, spraying, fertilizing, and other horticulture practices.
   b. After root pruning, backfill with good rooting medium, fertilize with organic fertilizer to promote root growth.
   c. Mulch to reduce weeds, discourage foot traffic, conserve moisture, and minimize temperature fluctuation.
2. Root Ball Size Chart: Root ball sizes shall be according to minimum standards set forth in Grades and Standards for Nursery Plants Part II, Palms and Trees, local state Department of Agriculture.
   a. Trees-Minimum Ball Sizes:

Caliper	Minimum Ball Diameter
3-1/2" to 4"	28"
4" to 4-1/2"	30"
4-1/2" to 5"	32"
5" to 5-1/2"	34"

Larger sizes increase proportionally.

   b. Minimum Ball Depth:

Ball Diameter	Depth
Less than 20"	Not less than 75 percent of diameter.
20" to 30"	Not less than 65 percent of diameter.
30" to 48"	Not less than 60 percent of diameter.

G. Crown Preparation
1. Shade and Flowering Trees

   a. Shade Trees: Selectively prune and thin crown to remove approximately one third of the branches. Preserve the basic shape and form of the tree, eliminate cross-branching and dead or diseased branches.
   b. Hand strip selected species of all leaves following pruning and before moving.
2. Palms: Follow standard procedure for transplantation of palms.

H. Hand Digging: Burlapping is required. Trees that are burlapped for relocation shall comply and be handled in same manner as new plant material specified in Section “Exterior Plants.”

I. Special Conditions
   1. Multi-Trunk Trees: Relocate multi-trunk tree as one unit. Measure unit by taking the aggregate total of all DBH measurements.
   2. Multi-Trunk Palms: Relocate multi-trunk palms as one unit. Unit shall be measured as follows:
      a. 50 percent of the value in dollars of the largest trunk in the grouping times the number of trunks in the clump.
   3. On-site relocation
      a. On-site relocation shall include root pruning, canopy pruning, on-site transportation, hauling and dumping of debris, and 90-day maintenance.
      b. If the tree or palm should die within the 90-day maintenance period, remove the tree, replace the material, and restore the site at no additional cost to the Owner.

J. Cleaning
   1. Cleaning up the Site
      a. Upon completion of the work, thoroughly clean up the project site.
      b. In addition to removing equipment, unused materials, deleterious material, and surplus excavated material, the Contractor shall fine grade all disturbed areas and the areas adjacent to the transplanted material to provide a neat and uniform site.
      c. All damaged or altered existing structures, as a result of the landscape work, shall be corrected.

END OF SECTION 32 91 13 16

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Task	Specification	Specification Description
32 91 13 26	32 91 13 16	Tree Relocation

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SECTION 32 91 13 33 - LAWNS AND GRASSES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for lawns and grasses. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Seeding.
b. Hydroseeding.
c. Sodding.
d. Plugging.
e. Sprigging.
f. Meadow grasses and wildflowers.
g. Turf renovation.
h. Erosion-control material(s).
i. Grass paving.

C. Definitions
1. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.
2. Finish Grade: Elevation of finished surface of planting soil.
3. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
4. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
5. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
6. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
7. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.
8. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
9. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.

D. Submittals
1. Product Data: For each type of product indicated.
2. Certification of Grass Seed.
a. Certification of each seed mixture for turfgrass sod **OR** plugs, **as directed**.
3. Product Certificates: For soil amendments and fertilizers, from manufacturer.
4. Maintenance Instructions: Recommended procedures to be established by the Owner for maintenance of turf and meadows during a calendar year. Submit before expiration of required initial maintenance periods.

E. Quality Assurance
1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
   a. Pesticide Applicator: State licensed, commercial.
2. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory.
   a. The soil-testing laboratory shall oversee soil sampling.
   b. Report suitability of tested soil for turf growth.
      1) State recommendations for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
      2) Report presence of problem salts, minerals, or heavy metals; if present, provide additional recommendations for corrective action.

F. Delivery, Storage, And Handling
1. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.
2. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod in time for planting within 24 hours of harvesting. Protect sod from breakage and drying.
3. Bulk Materials:
   a. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
   b. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
   c. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.

G. Maintenance Service
1. Initial Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 1.3. Begin maintenance immediately after each area is planted and continue until acceptable turf is established but for not less than the following periods:
   a. Seeded Turf: 60 days from date of planting completion **OR** Final Completion, **as directed**.
      1) When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.
   b. Sodded Turf: 30 days from date of planting completion **OR** Final Completion, **as directed**.
   c. Plugged Turf: 30 days from date of planting completion **OR** Final Completion, **as directed**.
   d. Sprigged Turf: 30 days from date of planting completion **OR** Final Completion, **as directed**.
2. Initial Meadow Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 1.3. Begin maintenance immediately after each area is planted and continue until acceptable meadow is established, but for not less than 40 days from date of planting completion **OR** Final Completion, **as directed**.
3. Continuing Maintenance Proposal: From Installer to the Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

1.2 PRODUCTS

A. Seed
1. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.
2. Seed Species: If grass seed is required to be certified by the State Department of Agriculture, State-certified seed of grass species as follows:
OR
Seed Species: If grass seed is not required to be certified by the State Department of Agriculture, seed of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed:
   a. Warm-season grass
      1) Full Sun: Bermudagrass (Cynodon dactylon).
   b. Cool-season grass
      1) Full Sun: Kentucky bluegrass (Poa pratensis), a minimum of three cultivars.
      2) Sun and Partial Shade: Proportioned by weight as follows:
         a) 50 percent Kentucky bluegrass (Poa pratensis).
         b) 30 percent chewings red fescue (Festuca rubra variety).
         c) 10 percent perennial ryegrass (Lolium perenne).
         d) 10 percent redtop (Agrostis alba).
      3) Shade: Proportioned by weight as follows:
         a) 50 percent chewings red fescue (Festuca rubra variety).
         b) 35 percent rough bluegrass (Poa trivialis).
         c) 15 percent redtop (Agrostis alba).
3. Grass Seed Mix: Proprietary seed mix as directed by the Owner.

B. Turfgrass Sod
1. Turfgrass Sod: Certified **OR** Approved **OR** Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects, **as directed**, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture, strongly rooted, and capable of vigorous growth and development when planted.
2. Turfgrass Species (warm-season grass): Bermudagrass (Cynodon dactylon) **OR** Carpetgrass (Axonopus affinis) **OR** Centipedegrass (Eremochloa ophiuroides) **OR** St. Augustinegrass (Stenotaphrum secundatum) **OR** Zoysiagrass (Zoysia japonica) **OR** Zoysiagrass (Zoysia matrella), **as directed**.
3. Turfgrass Species (cool-season grass): Sod of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed:
   a. Full Sun: Kentucky bluegrass (Poa pratensis), a minimum of three cultivars.
   b. Sun and Partial Shade: Proportioned by weight as follows:
      1) 50 percent Kentucky bluegrass (Poa pratensis).
      2) 30 percent chewings red fescue (Festuca rubra variety).
      3) 10 percent perennial ryegrass (Lolium perenne).
      4) 10 percent redtop (Agrostis alba).
   c. Shade: Proportioned by weight as follows:
      1) 50 percent chewings red fescue (Festuca rubra variety).
      2) 35 percent rough bluegrass (Poa trivialis).
      3) 15 percent redtop (Agrostis alba).

C. Plugs
1. Plugs: Turfgrass sod, certified **OR** approved **OR** Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects, **as directed**, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture, cut into square or round plugs, strongly rooted,

and capable of vigorous growth and development when planted; of the following turfgrass species and plug size:

a. Turfgrass Species (warm-season grass): Bermudagrass (Cynodon dactylon) **OR** Carpetgrass (Axonopus affinis) **OR** Centipedegrass (Eremochloa ophiuroides) **OR** St. Augustinegrass (Stenotaphrum secundatum) **OR** Zoysiagrass (Zoysia japonica) **OR** Zoysiagrass (Zoysia matrella), **as directed**.

b. Plug Size: 2 inches (50 mm) **OR** 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**.

D. Sprigs

1. Sod Sprigs: Healthy living stems, rhizomes, or stolons with a minimum of two nodes and attached roots free of soil, of the following turfgrass species:
   a. Turfgrass Species (warm-season grass): Bermudagrass (Cynodon dactylon) **OR** Carpetgrass (Axonopus affinis) **OR** Centipedegrass (Eremochloa ophiuroides) **OR** St. Augustinegrass (Stenotaphrum secundatum) **OR** Zoysiagrass (Zoysia japonica) **OR** Zoysiagrass (Zoysia matrella), **as directed**.
   b. Turfgrass Species (cool-season grass): Creeping bentgrass (Agrostis palustris).

E. Meadow Grasses And Wildflowers

1. Wildflower Seed: Fresh, clean, and dry new seed, of mixed species as directed.
2. Native Grass Seed: Fresh, clean, and dry new seed, of mixed species as directed.
3. Wildflower and Native Grass Seed: Fresh, clean, and dry new seed, of mixed species as directed.
4. Seed Carrier: Inert material, sharp clean sand or perlite, mixed with seed at a ratio of not less than two parts seed carrier to one part seed.

F. Inorganic Soil Amendments

1. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
   a. Class T, with a minimum of 99 percent passing through No. 8 (2.36-mm) sieve and a minimum of 75 percent passing through No. 60 (0.25-mm) sieve.
      OR
      Class O, with a minimum of 95 percent passing through No. 8 (2.36-mm) sieve and a minimum of 55 percent passing through No. 60 (0.25-mm) sieve.
   b. Provide lime in form of ground dolomitic limestone **OR** calcitic limestone **OR** mollusk shells, **as directed**.
2. Sulfur: Granular, biodegradable, containing a minimum of 90 percent sulfur, and with a minimum of 99 percent passing through No. 6 (3.35-mm) sieve and a maximum of 10 percent passing through No. 40 (0.425-mm) sieve.
3. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.
4. Aluminum Sulfate: Commercial grade, unadulterated.
5. Perlite: Horticultural perlite, soil amendment grade.
6. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through No. 50 (0.30-mm) sieve.
7. Sand: Clean, washed, natural or manufactured, and free of toxic materials.
8. Diatomaceous Earth: Calcined, 90 percent silica, with approximately 140 percent water absorption capacity by weight.
   OR
   Zeolites: Mineral clinoptilolite with at least 60 percent water absorption by weight.

G. Organic Soil Amendments

1. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch (25-mm) **OR** 3/4-inch (19-mm) **OR** 1/2-inch (12.5-mm), **as directed**, sieve; soluble salt content of 5 to 10

decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
a. Organic Matter Content: 50 to 60 percent of dry weight.
b. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

2. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture, with a pH range of 3.4 to 4.8.
3. Muck Peat: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1100 to 2000 percent.
4. Wood Derivatives: Decomposed, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.
   a. In lieu of decomposed wood derivatives, mix partially decomposed wood derivatives with ammonium nitrate at a minimum rate of 0.15 lb/cu. ft. (2.4 kg/cu. m) of loose sawdust or ground bark, or with ammonium sulfate at a minimum rate of 0.25 lb/cu. ft. (4 kg/cu. m) of loose sawdust or ground bark.
5. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

H. Fertilizers
1. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 1 **OR** 4, **as directed**, percent nitrogen and 10 **OR** 20, **as directed**, percent phosphoric acid.
2. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
3. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
   a. Composition: 1 lb/1000 sq. ft. (0.45 kg/92.9 sq. m) of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
   b. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.
4. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
   a. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
   OR
   Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

I. Planting Soils
1. Planting Soil: ASTM D 5268 topsoil, with pH range of 5.5 to 7, a minimum of 2 percent organic material content **OR** Existing, native surface topsoil formed under natural conditions with the duff layer retained during excavation process **OR** Existing, in-place surface soil **OR** Imported topsoil or manufactured topsoil from off-site sources; do not obtain from agricultural land, bogs or marshes, **as directed**. Verify suitability of soil to produce viable planting soil. Clean soil of roots, plants, sod, stones, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth. Mix soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
   a. Ratio of Loose Compost to Topsoil by Volume: 1:4 **OR** 1:3 **OR** 1:2, **as directed**.
   b. Ratio of Loose Sphagnum **OR** Muck, **as directed**, Peat to Topsoil by Volume: as directed by the Owner .
   c. Ratio of Loose Wood Derivatives to Topsoil by Volume: as directed by the Owner.
   d. Weight of Lime per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.

e. Weight of Sulfur **OR** Iron Sulfate **OR** Aluminum Sulfate, **as directed**, per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.
f. Weight of Agricultural Gypsum per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.
g. Volume of Sand Plus 10 Percent Diatomaceous Earth **OR** Zeolites, **as directed**, per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.
h. Weight of Bonemeal per 1000 Sq. Ft. (92.9 Sq. m)**:** as directed by the Owner.
i. Weight of Superphosphate per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.
j. Weight of Commercial Fertilizer per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.
k. Weight of Slow-Release Fertilizer per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.

J. Mulches
1. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.
2. Sphagnum Peat Mulch: Partially decomposed sphagnum peat moss, finely divided or of granular texture, and with a pH range of 3.4 to 4.8.
3. Muck Peat Mulch: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1100 to 2000 percent.
4. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch (25-mm) sieve; soluble salt content of 2 to 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
   a. Organic Matter Content: 50 to 60 percent of dry weight.
   b. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
5. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.
6. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.
7. Asphalt Emulsion: ASTM D 977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

K. Pesticides
1. General: Pesticide, registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
2. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
3. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

L. Erosion-Control Materials
1. Erosion-Control Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches (150 mm) long.
2. Erosion-Control Fiber Mesh: Biodegradable burlap or spun-coir mesh, a minimum of 0.92 lb/sq. yd. (0.5 kg/sq. m), with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, 6 inches (150 mm) long.
3. Erosion-Control Mats: Cellular, non-biodegradable slope-stabilization mats designed to isolate and contain small areas of soil over steeply sloped surface, of 3-inch (75-mm) **OR** 4-inch (100-mm) **OR** 6-inch (150-mm), **as directed**, nominal mat thickness. Include manufacturer's recommended anchorage system for slope conditions.

M. Grass-Paving Materials
1. Grass Paving: Cellular, non-biodegradable plastic mats, designed to contain small areas of soil and enhance the ability of turf to support vehicular and pedestrian traffic, of 1-inch (25-mm) **OR** 1-3/4-inch (45-mm) **OR** 2-inch (50-mm) **OR** manufacturer's standard, **as directed**, nominal mat thickness. Include manufacturer's recommended anchorage system for slope conditions.
2. Base Course: Sound crushed stone or gravel complying with ASTM D 448 for Size No. 8 **OR** Division 31 Section "Earth Moving" for base-course material, **as directed**.
3. Sand: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33 for fine aggregate.
4. Proprietary Growing Mix: As submitted and acceptable to the Owner.
5. Sandy Loam Soil Mix: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33 for fine aggregate blended with planting soil as specified. Use blend consisting of 1/2 sand and 1/2 planting soil **OR** 2/3 sand and 1/3 planting soil, **as directed**.
6. Soil for Paving Fill: Planting soil as specified.

1.3 EXECUTION

A. Preparation
1. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
   a. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
   b. Protect grade stakes set by others until directed to remove them.
2. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

B. Turf Area Preparation
1. Limit turf subgrade preparation to areas to be planted.
2. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 4 inches (100 mm) **OR** 6 inches (150 mm) **OR** 8 inches (200 mm), **as directed**. Remove stones larger than 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off the Owner's property.
   a. Apply superphosphate fertilizer directly to subgrade before loosening.
   b. Thoroughly blend planting soil off-site before spreading or spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil.
      1) Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
      2) Mix lime with dry soil before mixing fertilizer.
   c. Spread planting soil to a depth of 4 inches (100 mm) **OR** 6 inches (150 mm) **OR** 8 inches (200 mm), **as directed**, but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
      1) Spread approximately 1/2 the thickness of planting soil over loosened subgrade. Mix thoroughly into top 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**, of subgrade. Spread remainder of planting soil.
      2) Reduce elevation of planting soil to allow for soil thickness of sod.
3. Unchanged Subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
   a. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
   b. Loosen surface soil to a depth of at least 6 inches (150 mm) **OR** 8 inches (200 mm), **as directed**. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 4 inches (100 mm) **OR** 6 inches (150 mm), **as directed**, of soil. Till soil to a homogeneous mixture of fine texture.
      1) Apply superphosphate fertilizer directly to surface soil before loosening.
   c. Remove stones larger than 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, in any dimension and sticks, roots, trash, and other extraneous matter.

d. Legally dispose of waste material, including grass, vegetation, and turf, off the Owner's property.

4. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch (13 mm) of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit finish grading to areas that can be planted in the immediate future.
5. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
6. Before planting, obtain the Owner's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

C. Preparation For Erosion-Control Materials
1. Prepare area as specified in "Turf Area Preparation" Article.
2. For erosion-control mats, install planting soil in two lifts, with second lift equal to thickness of erosion-control mats. Install erosion-control mat and fasten as recommended by material manufacturer.
3. Fill cells of erosion-control mat with planting soil and compact before planting.
4. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions. Fasten as recommended by material manufacturer.
5. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

D. Preparation For Grass-Paving Materials
1. Reduce subgrade elevation soil to allow for thickness of grass-paving system. Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade so that installed paving is within plus or minus 1/2 inch (13 mm) of finish elevation. Roll and rake, remove ridges, and fill depressions.
2. Install base course **OR** sand course **OR** base course and sand course, **as directed**, and sandy loam soil mix **OR** proprietary growing mix **OR** soil for paving fill, **as directed**, as recommended by paving-material manufacturer for site conditions; comply with details shown on Drawings. Compact according to paving-material manufacturer's written instructions.
3. Install paving mat and fasten according to paving-material manufacturer's written instructions.
4. Before planting, fill cells of paving mat with planting soil **OR** sandy loam soil mix **OR** proprietary growing mix **OR** sand half full, **as directed**, and compact according to manufacturer's written instructions.
5. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

E. Seeding
1. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph (8 km/h). Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
   a. Do not use wet seed or seed that is moldy or otherwise damaged.
   b. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.
2. Sow seed at a total rate of 2 lb/1000 sq. ft. (0.9 kg/92.9 sq. m) **OR** 3 to 4 lb/1000 sq. ft. (1.4 to 1.8 kg/92.9 sq. m) **OR** 5 to 8 lb/1000 sq. ft. (2.3 to 3.6 kg/92.9 sq. m), **as directed**.
3. Rake seed lightly into top 1/8 inch (3 mm) of soil, roll lightly, and water with fine spray.
4. Protect seeded areas with slopes exceeding 1:4 with erosion-control blankets and 1:6 with erosion-control fiber mesh installed and stapled according to manufacturer's written instructions.
5. Protect seeded areas with erosion-control mats where shown on Drawings; install and anchor according to manufacturer's written instructions.
6. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre (42 kg/92.9 sq. m) to form a continuous blanket 1-1/2 inches (38 mm) in loose thickness over seeded areas. Spread by hand, blower, or other suitable equipment.

a. Anchor straw mulch by crimping into soil with suitable mechanical equipment.
b. Bond straw mulch by spraying with asphalt emulsion at a rate of 10 to 13 gal./1000 sq. ft. (38 to 49 L/92.9 sq. m). Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.

7. Protect seeded areas from hot, dry weather or drying winds by applying compost mulch **OR** peat mulch **OR** planting soil, **as directed**, within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch (4.8 mm), and roll surface smooth.

F. Hydroseeding

1. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
   a. Mix slurry with nonasphaltic **OR** asphalt-emulsion **OR** fiber-mulch manufacturer's recommended, **as directed**, tackifier.
   b. Apply slurry uniformly to all areas to be seeded in a one-step process. Apply slurry at a rate so that mulch component is deposited at not less than 1500-lb/acre (15.6-kg/92.9 sq. m) dry weight, and seed component is deposited at not less than the specified seed-sowing rate.

      OR

      Apply slurry uniformly to all areas to be seeded in a two-step process. Apply first slurry coat at a rate so that mulch component is deposited at not less than 500-lb/acre (5.2-kg/92.9 sq. m) dry weight, and seed component is deposited at not less than the specified seed-sowing rate. Apply slurry cover coat of fiber mulch (hydromulching) at a rate of 1000 lb/acre (10.4 kg/92.9 sq. m).

G. Sodding

1. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.
2. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to subgrade or sod during installation. Tamp and roll lightly to ensure contact with subgrade, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.
   a. Lay sod across angle of slopes exceeding 1:3.
   b. Anchor sod on slopes exceeding 1:6 with wood pegs or steel staples spaced as recommended by sod manufacturer but not less than 2 anchors per sod strip to prevent slippage.
3. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches (38 mm) below sod.

H. Plugging

1. Plant plugs in holes or furrows, spaced 12 inches (300 mm) **OR** 18 inches (450 mm), **as directed**, apart in both directions. On slopes, contour furrows to near level.

I. Sprigging

1. Plant freshly shredded sod sprigs in furrows 1 to 1-1/2 inches (25 to 38 mm) **OR** 1-1/2 to 2 inches (38 to 50 mm) **OR** 2-1/2 to 3 inches (64 to 75 mm), **as directed**, deep. Place individual sprigs with roots and portions of stem in moistened soil, 6 inches (150 mm) **OR** 12 inches (300 mm), **as directed**, apart in rows 10 inches (250 mm) **OR** 18 inches (450 mm), **as directed**, apart, and fill furrows without covering growing tips. Lightly roll and firm soil around sprigs after planting.
2. Broadcast sprigs uniformly over prepared surface at a rate of 10 cu. ft./1000 sq. ft. (0.28 cu. m/92.9 sq. m) and mechanically force sprigs into lightly moistened soil.
   a. Spread a 1/4-inch- (6-mm-) thick layer of compost mulch **OR** peat mulch **OR** planting soil, **as directed**, on sprigs.
   b. Lightly roll and firm soil around sprigs after planting.

c. Water sprigs immediately after planting and keep moist by frequent watering until well rooted.

J. Turf Renovation
1. Renovate existing turf.
2. Renovate existing turf damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.
   a. Reestablish turf where settlement or washouts occur or where minor regrading is required.
   b. Install new planting soil as required.
3. Remove sod and vegetation from diseased or unsatisfactory turf areas; do not bury in soil.
4. Remove topsoil containing foreign materials such as oil drippings, fuel spills, stones, gravel, and other construction materials resulting from Contractor's operations, and replace with new planting soil.
5. Mow, dethatch, core aerate, and rake existing turf.
6. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergence herbicides.
7. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off the Owner's property.
8. Till stripped, bare, and compacted areas thoroughly to a soil depth of 6 inches (150 mm).
9. Apply soil amendments and initial fertilizers required for establishing new turf and mix thoroughly into top 4 inches (100 mm) of existing soil. Install new planting soil to fill low spots and meet finish grades.
10. Apply seed and protect with straw mulch **OR** sod, **as directed**, as required for new turf.
11. Water newly planted areas and keep moist until new turf is established.

K. Turf Maintenance
1. Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.
   a. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
   b. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
   c. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
2. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches (100 mm).
   a. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
   b. Water turf with fine spray at a minimum rate of 1 inch (25 mm) per week unless rainfall precipitation is adequate.
3. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:
   a. Mow bentgrass to a height of 1/2 inch (13 mm) or less.
   b. Mow bermudagrass to a height of 1/2 to 1 inch (13 to 25 mm).
   c. Mow carpetgrass, centipedegrass, perennial ryegrass, and zoysiagrass to a height of 1 to 2 inches (25 to 50 mm).
   d. Mow Kentucky bluegrass, buffalograss, annual ryegrass, and chewings red fescue to a height of 1-1/2 to 2 inches (38 to 50 mm).

e. Mow bahiagrass, turf-type tall fescue, and St. Augustinegrass to a height of 2 to 3 inches (50 to 75 mm).

4. Turf Postfertilization: Apply fertilizer after initial mowing and when grass is dry.
   a. Use fertilizer that will provide actual nitrogen of at least 1 lb/1000 sq. ft. (0.45 kg/92.9 sq. m) to turf area.

L. Satisfactory Turf
1. Turf installations shall meet the following criteria as determined by Architect:
   a. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. (0.92 sq. m) and bare spots not exceeding 5 by 5 inches (125 by 125 mm).
   b. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.
   c. Satisfactory Plugged Turf: At end of maintenance period, the required number of plugs has been established as well-rooted, viable patches of grass, and areas between plugs are free of weeds and other undesirable vegetation.
   d. Satisfactory Sprigged Turf: At end of maintenance period, the required number of sprigs has been established as well-rooted, viable plants, and areas between sprigs are free of weeds and other undesirable vegetation.
2. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

M. Meadow
1. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph (8 km/h). Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
   a. Do not use wet seed or seed that is moldy or otherwise damaged.
2. Sow seed at a total rate of 4 oz./1000 sq. ft. (113 g/92.9 sq. m) **OR** 5 oz./1000 sq. ft. (142 g/92.9 sq. m) **OR** 6 oz./1000 sq. ft. (170 g/92.9 sq. m), **as directed**.
3. Brush seed into top 1/16 inch (1.6 mm) of soil, roll lightly, and water with fine spray.
4. Protect seeded areas from hot, dry weather or drying winds by applying peat or compost mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch (4.8 mm), and roll surface smooth.
5. Water newly planted areas and keep moist until meadow is established.

N. Meadow Maintenance
1. Maintain and establish meadow by watering, weeding, mowing, trimming, replanting, and performing other operations as required to establish a healthy, viable meadow. Roll, regrade, and replant bare or eroded areas and remulch. Provide materials and installation the same as those used in the original installation.
   a. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and meadow damaged or lost in areas of subsidence.
   b. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
   c. Apply treatments as required to keep meadow and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
2. Watering: Install and maintain temporary piping, hoses, and meadow-watering equipment to convey water from sources and to keep meadow uniformly moist.
   a. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
   b. Water meadow with fine spray at a minimum rate of 1/2 inch (13 mm) per week for four **OR** six **OR** eight, **as directed**, weeks after planting unless rainfall precipitation is adequate.

O. Pesticide Application
   1. Apply pesticides and other chemical products and biological control agents in accordance with requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with the Owner's operations and others in proximity to the Work. Notify the Owner before each application is performed.
   2. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

P. Cleanup And Protection
   1. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
   2. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.
   3. Remove nondegradable erosion-control measures after grass establishment period.

END OF SECTION 32 91 13 33

Task	Specification	Specification Description
32 91 13 33	31 13 13 00	Tree Protection And Trimming
32 91 13 33	31 01 20 00	Earthwork
32 91 13 33	31 23 16 26	Embankment
32 91 13 36	32 91 13 16	Tree Relocation
32 91 13 36	32 91 13 33	Lawns And Grasses

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SECTION 32 91 19 13 - CONCRETE REVETMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers installation of a concrete revetment. Work includes but is not limited to furnishing all labor, materials, equipment and supervision necessary to construct concrete revetment as follows or as directed by the Owner.

1.2 PRODUCTS

A. The Concrete Revetment shall be an articulating cellular concrete block system, as manufactured by American Excelsior Company, or approved equal, (800-713-8245), is a block structure installed over a geotextile fabric as described herein. The cellular blocks are made of Portland Cement Concrete cast into “lock” blocks and “key” blocks to provide a three directional interlock to resist lateral movement. The articulating cellular concrete block system is a “flexible” concrete revetment which allows the blocks to traverse changes in terrain without disruption of the placement pattern and interlock feature.
1. The minimum concrete strength shall be 3,000 psi. Nominal block thickness shall be either 4 inches, 6 inches or 8 inches, as required to meet project requirements. Block weights, per pair of “key” and “lock” blocks, shall be approximately 50, 70 and 90 pounds for #4010-4 inch, #4015-6 inch and #4020-8 inch thick blocks, respectively. Each pair of “key” and “lock” blocks shall cover approximately 1.54 square feet, including uncovered openings between the blocks. The system shall provide approximately 80 percent coverage of the area with blocks, leaving approximately 20 percent, but not less than 16 percent, uncovered area at the ground surface.

B. Filter fabric shall be Tri-Lock Fabric #792 as supplied by American Excelsior Company, or approved equal, (800) 713-8245; roll values:

Property	Specification	Test Method
Weight	7.4 oz/sy	ASTM D3776
Thickness	25 mils	ASTM D1777
Permeability	0.5 cm/sec	ASTM D4491
Abrasion Resistance	Warp: 58 percent	ASTM N3884
(% strength retained)	Fill: 81 percent	
Tensile Grab Strength	350 lbs. x 395 lbs	ASTM D4632
Grab Elongation	24% x 24%	ASTM D4632
Burst Strength	780 psi	ASTM D3786
Trapezoid Tear	120 lbs x 110 lbs.	ASTM D4533
Puncture Strength	165 lbs.	ASTM D4833
Apparent Opening Size	40-70	ASTM D-4751
UV Resistance @ 500 hours	90 percent	ASTM D-4355

C. Tri-Lock block size selection shall be determined from documented hydraulic characteristics, derived from test procedures outlined in: “Hydraulic Stability of Articulating Concrete block Revetment Systems During Overtopping Flow.” Report No. FHWA-RD-89-199, and “Minimizing Embankment Damage During Overtopping Flow.” Report No. FHWA-RD-88-181.

D. Backfill: Topsoil and seeding shall be as per Division 31 Section(s) "Earth Moving" AND Division 32 Section(s) "Turf And Grasses".

1.3 EXECUTION

A. Excavation shall be made so that the placement of the geotextile and concrete blocks shall be in conformity with the lines and grades shown on the plans or as required to meet project requirements. The area for placement shall be free from obstructions such as tree roots, projecting stones or other foreign matter and graded smooth. Voids or soft areas shall be filled with suitable materials and compacted to non-movement. Place the geotextile on the prepared subgrade. Lock the edges into a key trench as required to meet project requirements. The concrete blocks shall be assembled overlaying a geotextile in a manner that allows maximum flexibility but discourages vertical movement of any single component. Fill open areas of the blocks with concrete at the interface to concrete structure. After placement, the open areas of the block system shall be backfilled with topsoil to the top of the blocks. The backfilling shall be completed within 14 days of placement of the geotextile.

END OF SECTION 32 91 19 13

SECTION 32 91 19 13a - SEPTIC TANK SYSTEMS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for septic tank systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
   a. Septic tanks.
   b. Distribution boxes.
   c. Pipe and fittings.
   d. Absorption systems

C. Submittals
1. Product Data: For each type of product indicated.
   a. Include construction details, material descriptions, dimensions of individual components, and profiles.
   b. Include manhole openings, covers, and pipe connections.
2. Shop Drawings: For [trench absorption systems] [bed absorption systems].
   a. Include manhole openings, covers, pipe connections, and accessories.
   b. Include piping with sizes and invert elevations.
   c. Include underground structures.
   d. Include other utilities.

1.2 PRODUCTS

A. Septic Tanks
1. Precast Concrete Septic Tanks: ASTM C 1227, single-chamber **OR** two-chamber, **as directed**, precast, reinforced-concrete tank with internal baffle, **as directed**, and covers.
   a. Design: For A-8 (H10-44) **OR** A-12 (HS15-44) **OR** A-16 (HS20-44), **as directed,** traffic loading according to ASTM C 890.
   b. Manholes: 20-inch- (508-mm-) **OR** 22-inch- (559-mm-) **OR** 24-inch- (610-mm-), **as directed,** minimum diameter opening with reinforced-concrete risers to grade and access lid with steel lift rings. Include manhole in center of each septic tank compartment top.
   c. Filter Access: Reinforced-concrete access hole, large enough to remove filter, over filter position.
   d. Inlet and Outlet Access: 12-inch- (300-mm-) minimum diameter, reinforced-concrete access lids with steel lift rings. Include access centered over inlet and outlet.
   e. Resilient Connectors: ASTM C 923 (ASTM C 923M), of size required for piping, fitted into inlet and outlet openings.
2. Fiberglass Septic Tanks: UL 1316, single-chamber, FRP construction; fabricated for septic tank application with at least one access riser and manhole.
   a. Manholes: 22-inch- (559-mm-) **OR** 24-inch- (610-mm-), **as directed,** minimum diameter opening with FRP access risers to grade and cover.
   b. Filter Access: Include access hole, large enough to remove filter, over filter position.
   c. Resilient Connectors: ASTM C 923 (ASTM C 923M) or other watertight seal, of size required for piping, fitted into inlet and outlet openings.
3. Polyethylene Septic Tanks: Single-chamber, molded, HDPE or PE construction; fabricated for septic tank application, with baffle, **as directed**, and at least one access riser and manhole.

4. Polyethylene Septic Tanks: Two-chamber, molded, HDPE or PE construction; fabricated for septic tank application, with access risers and manholes.
   a. Manholes: 18-inch- (457-mm-) **OR** 20-inch- (508-mm-) **OR** 22-inch- (559-mm-), **as directed,** minimum diameter opening with HDPE or PE access risers to grade and cover.
   b. Filter Access: Include access hole, large enough to remove filter, over filter position.
   c. Resilient Connectors: ASTM C 923 (ASTM C 923M) or other watertight seal, of size required for piping, fitted into inlet and outlet openings.

B. Filters
1. Description: Removable, septic-tank-outlet filter that restricts discharge solids to 1/8 inch (3.2 mm).
   a. Housing: HDPE or PVC.
   b. Outlet Size: NPS 4 (DN 100) **OR** NPS 6 (DN 150), **as directed.**

C. Dosing Tanks
1. Dosing Tanks: Comply with ASTM C 913 for precast, reinforced-concrete tank and cover; designed for structural loading according to ASTM C 890.
   a. Design: For effluent pump, **OR** automatic siphon, **as directed,** installation and A-8 (H10-44) **OR** A-12 (HS15-44) **OR** A-16 (HS20-44), **as directed,** traffic loading according to ASTM C 890.
   b. Manholes: 20-inch- (508-mm-) **OR** 22-inch- (559-mm-) **OR** 24-inch- (610-mm-), **as directed,** minimum diameter opening with reinforced-concrete risers to grade and access lid with steel lift rings. Include manhole in center of each septic tank compartment top.
   c. Resilient Connectors: ASTM C 923 (ASTM C 923M), of size required for piping, fitted into inlet and outlet openings.

D. Automatic Siphons
1. Description: Manufactured siphon assembly of molded-HDPE trap, pipe, and bell, with PVC vent piping and stainless-steel bolts.

E. Distribution Boxes
1. Description: Precast concrete, single-chamber box and cover.
   a. Design: Made according to ASTM C 913, and for A-8 (H10-44) **OR** A-12 (HS15-44) **OR** A-16 (HS20-44), **as directed,** traffic loading according to ASTM C 890. Include baffle opposite inlet.
   b. Manholes: 20-inch- (508-mm-) **OR** 22-inch- (559-mm-) **OR** 24-inch- (610-mm-), **as directed,** minimum diameter opening with reinforced-concrete risers to grade and cover with steel lift rings in center of distribution box cover.
   c. Pipe Connections: ASTM C 923 (ASTM C 923M) resilient connectors, of size required for piping, fitted into inlet and outlet openings. Include watertight plugs in outlets not required.
2. Description: Molded-HDPE or -PE, single-chamber box and cover.
   a. Manholes: 18-inch- (457-mm-) **OR** 20-inch- (508-mm-) **OR** 22-inch- (559-mm-), **as directed,** minimum diameter opening with HDPE or PE access risers to grade and cover. Access for PE distribution boxes may be a removable plastic cover and is usually small.
   OR
   Manufacturer's standard cover or other access opening of size that permits access to distribution-box inlet and outlets.
   b. Pipe Connections: With seal that prevents leakage. Include watertight plugs in outlets not required.

F. Leaching Pipes And Fittings
1. Pipe: PE, complying with ASTM F 810, perforated.
   a. Fittings: ASTM D 2729 PVC for loose joints; ASTM D 3034, PVC for gasketed joints; or ASTM D 2751, ABS for gasketed joints.

2. Tube and Fittings: PE, complying with ASTM F 405, perforated corrugated tube with solid-wall fittings.
   a. Couplings: PE band, matching tube and fitting dimensions.
3. Pipe and Fittings: PVC, complying with ASTM D 2729, perforated, for solvent-cement joints.
   a. Solvent Cement: ASTM D 2564. Include primer according to ASTM F 656
4. Drainage Tile: Clay drain tile, complying with ASTM C 4, Standard class, drain tile with regular and smooth ends, for open joints.

G. Nonpressure-Type Pipe Couplings
1. Description: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant-metal tension band and tightening mechanism on each end.
   a. Sleeve Materials:
      1) For Concrete Pipes: ASTM C 443 (ASTM C 443M), rubber.
      2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
      3) For Vitrified-Clay Pipes: ASTM C 425, rubber.
      4) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

H. Leaching Chambers
1. Description: Arched, molded-PE structures with solid top, perforated sides, open ends, and open bottom.
   a. End Pieces: Solid and solid with pipe opening types.
   b. Effluent Distribution Piping: PE or PVC pipe, with holes or slots along pipe, attached to underside of top of chambers.

I. Trench **OR** Bed, **as directed,** Absorption-System Materials
1. Filtering Material: ASTM D 448, Size No. 24, 3/4 to 2-1/2 inches (19 to 63 mm), washed, crushed stone or gravel; or broken, hard-burned clay brick.
2. Filter Mat: Geotextile woven or spun filter fabric, in 1 or more layers, for minimum total unit weight of 3 oz./sq. yd. (101 g/sq. m) **OR** Untreated building paper or similar porous material, **as directed**.
3. Cover for Distribution Pipe: Geotextile woven filter fabric, in 1 or more layers, for minimum total unit weight of 3 oz./sq. yd. (101 g/sq. m).
4. Fill Material: Soil removed from trench.

J. Mound Absorption-System Materials
1. Sand Filtering Material: 25 percent or more of very coarse, coarse, or medium sand or combination; maximum of 50 percent fine or very fine sand or combination; and silt and clay combination not to exceed 25 percent. If clay exceeds 60 percent in combination with silt, mixture cannot exceed 15 percent of sand filtering material.
2. Aggregate Filtering Material: Coarse, 1/2 to 2-1/2 inches (13 to 63 mm).
3. Cap: Clay, silt, or combination of clay and silt.
4. Topsoil: Good quality, free of stones, metal, and glass.
5. Vegetation Cover: Grass compatible with adjacent ground cover. No shrubs or trees.
6. Filter Mat: Geotextile woven or spun filter fabric, in 1 or more layers, for minimum total unit weight of 3 oz./sq. yd. (101 g/sq. m) **OR** Untreated building paper or similar porous material, **as directed**.
7. Cover for Distribution Pipe: Geotextile woven filter fabric, in 1 or more layers, for minimum total unit weight of 3 oz./sq. yd. (101 g/sq. m).

K. Chamber Absorption-System Materials
1. Chamber: Arched, molded-PE structures with solid top, perforated sides, open ends, and open bottom.
2. End Pieces: Blank without opening for distribution pipe at end of last chamber in row, and with opening for distribution pipe where pipe penetrates chamber.

3. Retain first paragraph below to run piping through chambers to improve distribution.
4. Effluent Distribution Piping: PE or PVC pipe, with holes or slots along pipe, attached to underside of top of chambers.

L. Seepage Pit Absorption-System Materials
1. Constructed-in-Place-Type Seepage Pit: Include the following materials.
   a. Pit Lining: ASTM C 62, Type SW, clay bricks; ASTM C 55, concrete bricks; ASTM C 90, hollow, concrete masonry units; or precast concrete rings with notches or weep holes.
   b. Filtering Material: ASTM D 448, Size No. 24, 3/4 to 2-1/2 inches (19 to 63 mm), washed, crushed stone or gravel; or broken, hard-burned clay brick.
   c. Cover: Precast concrete slab; designed for A-8 (H10-44) **OR** A-12 (HS15-44) **OR** A-16 (HS20-44), **as directed,** traffic loading according to ASTM C 890 and made according to ASTM C 913. Include slab dimensions that will extend minimum of 12 inches (300 mm) beyond edge of excavation. Cast cover with opening for manhole in center.
   d. Manholes: 20-inch- (508-mm-) **OR** 22-inch- (559-mm-) **OR** 24-inch- (610-mm-), **as directed,** minimum diameter opening with reinforced-concrete risers to grade and access lid with steel lift rings.

1.3 EXECUTION

A. Earthwork
1. Excavating, trenching, and backfilling for piping and seepage pits are specified in Division 31 Section "Earth Moving".
   a. Stockpile topsoil for reuse in finish grading without intermixing with other excavated material. Stockpile materials away from edge of excavation and do not store within drip line of remaining trees.
   b. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
2. Excavating and Backfilling for Septic and Dosing Tanks:
   a. Excavate sufficient width and length for tanks to depth determined by tank inlet elevation. Provide level bottom.
   b. Backfill with excavated soil, mounding soil above original grade without compacting.
3. Excavating and Backfilling for Trench **OR** Bed, **as directed,** Absorption Fields:
   a. Excavate for trench absorption fields 30 inches (760 mm) wide and 24 inches (600 mm) deep, minimum.
   b. Backfill trench absorption fields with excavated soil, mounding soil above original grade without compacting.
   c. Excavate for bed absorption fields of width indicated and 24 inches (600 mm) deep, minimum.
   d. Backfill bed absorption fields with excavated soil, mounding soil above original grade without compacting.

B. Excavating and Backfilling for Chamber Absorption Systems:
1. Excavate for trench-type chamber absorption systems **30 inches (762 mm)** wide and **24 inches (610 mm)** deep, minimum.
2. Excavate for bed-type chamber absorption systems of width indicated and **24 inches (610 mm)**deep, minimum.
3. Backfill chamber absorption systems with excavated soil, mounding soil above original grade without compacting.

C. Excavating and Backfilling for Seepage-Pit Absorption Systems:
1. Excavate sufficient hole diameter for pits to depth determined by tank inlet and bottom elevations. Provide level bottom.
2. Backfill with excavated soil, mounding soil above original grade without compacting.

D. Septic Tank Installation
1. Install precast concrete septic tanks level according to ASTM C 891.
2. Install septic tanks level.
3. Connect septic tank to concrete ballast pad.
4. Install filter in septic tank outlet. Secure filter to septic tank wall. Make direct connections to distribution piping.
5. Install insulation on exterior sides and top of septic tank.
6. Fill septic tank with water.

E. Dosing Tank Installation
1. Install dosing tanks level and according to ASTM C 891.
2. Install automatic siphons embedded in precast concrete dosing tank. Make direct connections to distribution piping.
3. Set submersible effluent pumps on dosing tank floor. Make direct connections to distribution piping.
4. Fill dosing tanks with water.

F. Distribution Box Installation
1. Install precast concrete distribution boxes according to ASTM C 891 and at invert elevations indicated. Set level and plumb.
2. Install PE distribution boxes at invert elevations indicated and according to manufacturer's written instructions. Set level and plumb.

G. Piping Installation
1. Install leaching piping according to the following:
   a. Use perforated pipe and fittings for trench **OR** bed **OR** mound, **as directed,** absorption fields with perforations at bottom.
   b. PE Tube and Fittings: ASTM F 481.
   c. PVC Sewer Pipe and Fittings: ASTM F 481.

H. Pipe Joint Construction
1. Basic piping joint construction is specified in Division 33 Section "Common Work Results For Utilities". Where specific joint construction is not indicated, follow piping manufacturer's written instructions.
2. Join distribution piping with or according to the following:
   a. Install leaching pipe and fittings for trench OR bed OR mound, as directed, absorption fields with closed joints, unless otherwise indicated.
   b. PE Tube and Fittings: With PE band couplings.
   c. PVC Sewer Pipe and Fittings: With solvent-cemented joints according to ASTM F 402 and ASTM D 2321.
3. Join dissimilar pipe materials according to ASTM D 5926, with couplings and gaskets compatible with pipe materials being joined.

I. Cleanout Installation
1. Install cleanouts according to the following:
   a. Inlet and Outlet of Septic Tanks: Cast-iron cleanouts.
   b. Inlet and Outlet of Dosing Tanks: Cast-iron cleanouts.
   c. Inlet and Outlet of Distribution Boxes: Cast-iron **OR** PVC cleanouts.
   d. At Each Change in Direction of Sewer Piping: Cast-iron **OR** PVC cleanouts.
   e. At Ends of Each Row and at Each Change in Direction of Distribution Piping: Cast-iron **OR** PVC cleanouts.
2. Cast-Iron Cleanouts: Install with PVC fitting riser from distribution and leaching piping to cast-iron cleanout housing at grade. Use NPS 4 (DN 100) PVC sewer pipe and fittings with solvent-cemented joints for risers. Attach riser to cleanout housing with rubber gasket or coupling.

3. PVC Cleanouts: Install with PVC riser from distribution and leaching piping to PVC cleanout at grade. Use NPS 4 (DN 100) PVC sewer pipe and fittings with solvent-cemented joints for risers and cleanout fitting.
4. Cleanout Support: Set cleanouts in concrete blocks 18 by 18 by 12 inches (457 by 457 by 305 mm) deep, unless location is in concrete pavement. Formwork, reinforcement, and concrete are specified in Division 03 Section "Cast-in-place Concrete".
5. Set top of cleanout 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed,** above surrounding rough grade, or set flush with grade if installed in pavement.

J. Trench **OR** Bed **OR** Absorption-Field, **as directed,** Installation
1. Filtering Material: Place supporting layer of filtering material over the compacted trench **OR** bed, **as directed,** base to a compacted depth not less than 6 inches (150 mm) below bottom of pipe.
2. Refer to Part 1.3 "Piping Installation" and "Pipe Joint Construction" articles for specific piping material installation.
3. Install distribution piping at minimum slope of 1 percent and maximum slope of 2 percent.
4. Install leaching piping solidly bedded in filtering material, with full bearing for each pipe section throughout its length. Maintain pipe alignment with no slope.
   a. Install perforated pipe with perforations down and joints tightly closed. Install collars and couplings as required.
   b. Install open-joint pipe with 1/2-inch (13-mm) space, maximum, between ends, unless otherwise indicated. Cover top two-thirds of joint opening with joint cover, and tie with corrosion-resistant wire. Commercial joint-cover assemblies may be provided.
   c. Install elbow fittings with tight joints.
   d. Place additional filtering material around sides to a minimum compacted depth of 8 inches (200 mm) above the top of leaching piping.
5. Install filter mat over filter material before backfilling.
6. Install leaching chambers with no slope in bottom of trench **OR** bed, **as directed**.
   a. Install leaching chamber distribution piping with tight joints throughout chambers.
7. Backfill according to Part 1.3 "Earthwork" Article.

K. Mound Absorption-Field Installation
1. Plow top 6 inches (150 mm) of surface.
2. Place layers of sand, aggregate, **as directed**, cap, and topsoil above plowed area. Provide grass topping to match adjacent vegetation. Provide side slope not steeper than 3:1. Tie slope toe smoothly into existing grade.
3. Refer to Part 1.3 "Piping Installation" and "Pipe Joint Construction" articles for specific piping material installation.
4. Provide solid vent pipe with vent cap extending 12 inches (300 mm) above top of mounds.
5. Install distribution piping with no slope for pressurized effluent system.
6. Install distribution piping at a minimum slope of 1 percent and a maximum slope of 2 percent for gravity effluent system.
7. Install leaching piping solidly bedded in filtering material, with full bearing for each pipe section throughout its length. Maintain pipe alignment with no slope.
   a. Install perforated pipe with perforations down and joints tightly closed. Install collars and couplings as required.
   b. Install open-joint pipe with 1/2-inch (13-mm) space, maximum, between ends, unless otherwise indicated. Cover top two-thirds of joint opening with joint cover, and tie with corrosion-resistant wire. Commercial joint-cover assemblies may be provided.
   c. Install elbow fittings with tight joints.
8. Install leaching chambers with no slope above plowed area.
   a. Install leaching chamber distribution piping with tight joints throughout chambers.
9. Provide adequate grading around mound absorption field to prevent storm runoff from washing away a portion of mound absorption field and to prevent exposing pipes.

L. Seepage Pit Installation

1. Excavate hole to minimum diameter of 6 inches (150 mm) greater than outside of pit lining.
2. Do not extend pit depth into ground-water table.
3. Install constructed-in-place seepage pits according to the following procedure if no requirements of authorities having jurisdiction apply:
   a. Install brick pit lining material dry and laid flat with staggered joints for seepage.
   b. Install block pit lining material dry with staggered joints and a minimum of 20 percent of blocks on side for seepage. Install precast concrete rings with notches or weep holes for seepage.
   c. Extend pit lining material so top of manhole will be approximately 8 inches (200 mm) below finished grade.
   d. Backfill bottom of inside of pit with filtering material at least 12 inches (300 mm) above bottom of lining material.
   e. Extend effluent inlet pipe 12 inches (300 mm) into seepage pit and terminate into side of tee fitting.
   f. Backfill around outside of pit lining with filtering material to top of lining.
   g. Install manhole risers from top of pit to grade. Support cover on undisturbed soil. Do not support cover on pit lining.

M. Identification
1. Identification materials and their installation are specified in Division 31 Section "Earth Moving". Arrange for installation of green warning tape directly over piping (including absorption-field piping), at outside edges of underground structures, and at outside edges of absorption fields.
2. Use detectable warning tape over piping, over edges of underground structures, and over edges of absorption fields.

N. Field Quality Control
1. System Tests: Perform testing of completed septic tank system piping and structures according to authorities having jurisdiction.
2. Additional Tests: Fill underground structures with water and let stand overnight. If water level recedes, locate and repair leaks and retest. Repeat tests and repairs until no leaks exist.

O. Cleaning
1. Clear interior of piping and structures of dirt and other superfluous material as work progresses.
2. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of workday or when work stops.

END OF SECTION 32 91 19 13a

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Task	Specification	Specification Description
32 91 19 13	02 41 13 13a	Portland Cement Concrete Removal
32 91 19 13	31 11 00 00	Site Clearing
32 91 19 13	31 13 13 00	Tree Protection And Trimming
32 91 19 13	31 01 20 00	Earthwork
32 91 19 13	31 23 16 26	Embankment
32 91 19 13	32 91 13 33	Lawns And Grasses
32 92 16 00	32 91 13 33	Lawns And Grasses
32 92 19 13	32 91 13 33	Lawns And Grasses
32 92 19 19	32 91 13 33	Lawns And Grasses
32 92 23 00	32 91 13 33	Lawns And Grasses
32 93 13 00	32 14 09 00	Exterior Plants
32 93 23 00	32 14 09 00	Exterior Plants
32 93 33 00	31 11 00 00	Site Clearing
32 93 33 00	32 14 09 00	Exterior Plants
32 93 43 00	32 14 09 00	Exterior Plants
32 93 83 00	31 13 13 00	Tree Protection And Trimming
32 93 83 00	32 91 13 16	Tree Relocation
32 93 83 00	32 14 09 00	Exterior Plants
32 94 13 00	32 14 09 00	Exterior Plants
32 94 16 00	32 14 09 00	Exterior Plants
32 94 43 00	01 22 16 00	No Specification Required
32 94 43 00	32 33 13 00	Miscellaneous Site and Street Furnishings
32 94 49 00	01 22 16 00	No Specification Required
32 94 49 00	31 13 13 00	Tree Protection And Trimming
32 94 49 00	32 14 09 00	Exterior Plants
32 96 33 00	32 91 13 16	Tree Relocation
32 96 43 00	32 91 13 16	Tree Relocation

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SECTION 33 01 10 58 - REPAIR AND MAINTENANCE OF IMHOFF TANKS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for repair and maintenance of sewage treatment plant Imhoff tanks. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Coatings:
1. Epoxy-Filler Compound for concrete surfaces shall comply with Fed. Spec. MMM-A-001993.
2. Coal-Tar Epoxy shall comply with SSPC-PAINT 16.
3. Epoxy Paint shall comply with Mil. Spec. MIL-P-24441.
4. Red-Lead Base Paint shall comply with Fed. Spec. TT-P-86, Type I.
5. Aluminum Finish Paint shall comply with Fed. Spec. TT-P-38.

B. Steel Tank Repair Material for minor leaks shall be a two-component epoxy sealing compound. For badly corroded areas, a steel plate of the same composition and thickness as the original tank shall be used.

C. Pipe and Fittings for replacement shall be equivalent to the existing pipe and fittings.

1.3 EXECUTION

A. Preparation: Drain the contents of the tank and dispose of the sludge and sewage.

B. Leak Repair:
1. Concrete Tanks: Repair concrete tank leaks by cleaning and chipping or sandblasting the area of the leak and applying two-component epoxy concrete sealant.
2. Steel Tanks: Repair steel tank leaks by cleaning, scraping, chipping, or sandblasting the area of the leak and applying epoxy steel sealant. Repair badly corroded areas of steel tanks by cutting out the corroded area and welding a section of new steel plate in place. Welding shall be in compliance with AWS D1.1.

C. Pipe and Fittings: Replace pipe and fittings as required.

D. Cleaning and Coatings:
1. Interior Concrete Surfaces of the tank shall be cleaned with high pressure water or steam to remove dirt and residue, allowed to dry, and brush sandblasted.
2. Holes and Voids in the concrete surfaces left from the blast cleaning shall be filled by means of troweling and squeeze application of epoxy filler. Two coats of coal-tar epoxy shall be applied to the surface after the epoxy has cured.
3. Submerged Ferrous Metal Surfaces such as piping and equipment that are exposed to the sewage shall be sandblasted and coated with two coats of coal-tar epoxy.

4. Exterior Concrete Surfaces of the tank shall be cleaned by means of brush sandblast. The surfaces shall be blown down with air to remove the blasting residue and dust, and two coats of epoxy-polyamide paint shall be applied.
5. Ferrous Metal Surfaces that are not submerged shall be cleaned by means of sandblasting. Coat surfaces with one coat of red-lead base paint. After the base paint has dried sufficiently, apply two coats of aluminum finish paint.

END OF SECTION 33 01 10 58

SECTION 33 01 10 58a - SEWER LINE CLEANING

1.1 GENERAL

A. Description Of Work
1. This specification covers sewer line cleaning. Cleaning procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals: Submit product data and manufacturer's instruction.

1.2 PRODUCTS

A. All materials shall be clean, free of defects, corrosion, and damage. All items shall be of proper type, size, design, and characteristics for the use intended. Unless otherwise specified, all items shall be factory-made.

B. Portable Cleaning Equipment: Equipment used in the cleaning of sewer lines shall be as required to complete the work for the size, length, and conditions of the sewer. Portable and mobile equipment shall comply with Water Pollution Control Federation Manual No. 7.

C. Chemicals shall be of the strength required to perform the work. The chemicals shall not be damaging to pipe materials, manholes, pumping equipment, nor treatment process and shall not be contaminated by foreign substances.

1.3 EXECUTION

A. Preparation
1. Protection required to prevent damage to adjacent materials, equipment, fixtures, and finishes shall be provided. Necessary protective clothing and accessories for personnel working with chemicals shall be provided.
2. Ventilation of Sewers: Contractor shall provide proper ventilation for personnel working in the sewer.
3. Alternate Sewage Discharge: Contractor shall provide an alternate routing of sewage discharge to a downstream manhole.
4. Traffic: Contractor shall provide all traffic signs required to safely direct traffic at and around work areas.

B. Installation
1. Direction of Work: Sewer line cleaning work, with the exception of hydraulic scouring, shall proceed in the downstream direction. Cleaning by hydraulic scouring shall proceed in the upstream direction.
2. Testing: Upon completion of cleaning operation, test sewer lines for proper operation and observe for a period of 24 hours. Clean out all stoppages and the retest the line for proper operation.

END OF SECTION 33 01 10 58a

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Task	Specification	Specification Description
33 01 10 58	21 05 23 00	Piped Utilities Basic Materials And Methods

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SECTION 33 01 10 71 - PIPE LINING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of pipe lining. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

1.2 PRODUCTS

A. Lining Material:
1. Polyethylene Pipe: Extruded, flexible industrial grade, high density (Type 3 or 4) in 40 foot lengths, complying with ASTM D 2239 and D 2447.
a. Diameter: Outside diameter shall be as large as possible while allowing for ease of pulling into the existing pipes. Pipe dimensions shall comply with ASTM D 2447 and D 2837.
b. Liner Thickness and Class shall be suitable for the use intended. The tolerance on the pipe wall thickness shall be as noted in Table 2 of ASTM D 2447.
c. Gravity Sanitary, Gravity Storm, and Gravity Industrial Sewers shall be Schedule 40.
d. Gravity Thermal Discharge Sewers shall be Schedule 80.
e. Low Pressure Sewers shall be Schedule 40, complying with ASTM D 2239.
f. High Pressure Sewers shall be Schedule 80, complying with ASTM D 2239 and D 2837.
g. Chemical Resistance: Pipe liner shall be resistant to chemical attack, erosion, and corrosion.
h. Fittings shall be fabricated from polyethylene pipe. The polyethylene fittings shall have the same pressure rating as the pipe and shall comply with ASTM D 3261.
2. Cement-Mortar Lining:
a. Portland Cement shall comply with ASTM C 150, Type 1.
b. Pozzolan Cement shall comply with ASTM C 618 and shall not comprise more than 20 percent of total cement amount, by weight.
c. Sand shall be well graded, clean, free from organic and extraneous matter. One hundred percent shall pass the 16-mesh size screen.
d. Lining Thickness: Cement lining shall be not less than 1/8 inch for pipe sizes 4 to 14 inches, not less than 3/16 inch for pipe sized 16 inches and larger, and not less than 1/4 inch for steel pipe 16 inches and larger.
3. Reinforced Mortar Pipe Slip-Lining:
a. Gravity Sewers: Slip-lining shall be of glass fiber reinforced polyester mortar pipe, complying with ASTM D 3262.
b. Pressure Sewers (Force Mains): Slip-lining shall be of glass fiber reinforced polyester mortar pipe complying with ASTM D 2517.
c. Diameter: Outside diameter shall be as large as possible while allowing for ease of pulling into existing pipes, as recommended by the manufacturer.
d. Chemical Resistance: Pipe liner shall be resistant to chemical attack, erosion, and corrosion.
4. Fittings: Fittings shall be manufactured of the same materials as is the glass fiber reinforced polyester mortar pipe.
5. Epoxy-Mortar Lining:
a. Epoxy compound shall comply with ASTM D 1763.
b. Admixtures shall be well graded with one hundred percent passing. The 16-mesh size screen. All admixtures shall improve the workability, density, and strength of the mortar.

c. Lining Thickness: For pipe sizes 4 to 14 inches, epoxy mortar lining thickness shall be not less than 1/8 inch. For pipe sizes 16 inches and larger, epoxy mortar lining shall be not less than 3/16 inch.

B. Joint:
1. Slip-Lining:
a. Polyethylene Pipe Butt Joints: Pipe lengths, fittings, and flanged connections to be joined by thermal butt fusion shall be of the same time, grade, and class of polyethylene compound and supplied by pipe supplier.
b. Flanged Joints shall consist of a polyethylene flange, thermally butt fused to the ends of the pipe. The companion flange shall be steel or cast iron and nylon-coated.
c. Lateral Service Connections: Sidewall connections shall be made with polyethylene pipe sections of the same material, grade, and class as the liner material and shall have the same pressure ratings. Lateral connections shall be watertight.
2. Reinforced Mortar Lining:
a. Bell and spigot joints shall be the inverted type.
b. Manhole Joints and Connections shall be oakum ring and grout as required.

1.3 EXECUTION:

A. Slip-Lining, Polyethylene Pipe:
1. Insertion of Liner: Liner shall be laid at a constant line and grade as the existing pipe, without undulations or damage. Where the existing pipe is not at constant grade, the liner shall follow as true a constant grade as possible.
2. Grouting: At manholes, annular space shall be packed with oakum and expansion grout or nonshrink grout as required. At existing line, after liner has been inserted, grout wherever existing pipe has failed structurally.
3. Concrete Encasement: Crown of liner shall be encased in concrete a minimum thickness of 6 inches for the entire length of the excavated trench and out at least 6 inches each side of the bottom half of the original pipe remaining down to firm soil. Wherever existing concrete encasement has been removed, the liner shall be encased in the same manner as the original pipe.
4. Thrust Blocks: Concrete thrust blocks shall be provided as required.

B. Cement Mortar and Epoxy Mortar Lining:
1. Cement Mortar Mixing: One part cement to one and one-half parts of sand by volume.
2. Application of Lining: The lining shall be applied to produce a smooth, uniform thickness throughout the interior of the pipe line.
3. Curing of the Cement Mortar Lining: Immediately upon completion of the lining of a length of pipe between access openings or at the end of a day's run, the section of pipe shall be closed at each end, the access openings covered to prevent the circulation of air, and the atmosphere kept moist.
4. Reconnection of Pipes After Lining: Close and make watertight all openings in the lines.
5. Pressure Test and Leaks: Hydrostatic and leakage tests shall be conducted on all pipe that is cleaned and lined.

C. Reinforced Mortar Pipe Lining:
1. Joining of Pipe Ends: Liner sections containing bell and spigot joints shall be joined using an O-ring.
2. Grouting Work shall be accomplished following the same techniques as described in paragraph Slip-Lining, Polyethylene Pipe.

D. Cement Mortar Lining:

1. Epoxy Mortar Lining: Excessive mortar shall be removed from the manhole walls and bottom. Manhole bottom shall receive special care in making all transitions smooth.
2. Work at Service Connections: Plugs or caps shall be placed at the access point of the service connection to the lines and shall be removed once the mortar has set. The completed lining shall not be damaged.
3. Reinforced Mortar Pipe Lining: Joining of fiberglass reinforced polyester mortar pipe shall be carried out in the trench, with the first section of liner already inserted.
4. Lateral Connections: Service to connections shall be provided for and continued after installation of the lining.
5. Testing: Upon completion of lining operation, the sewer line shall be tested for proper operation and shall be observed for a period of 24 hours. All deficiencies shall be corrected.
6. Pavement Restoration: All disturbed pavement shall be restored to its original condition and shall match existing adjacent.
7. Inspection: Large diameter sewers shall be inspected from inside to ensure that all lateral connections and joints are in proper order. Sewers that have been cement-lined may be inspected for a smooth finish, while plugs and caps are being removed.

END OF SECTION 33 01 10 71

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Task	Specification	Specification Description
33 01 10 71	01 22 16 00	No Specification Required
33 01 10 71	21 05 23 00	Piped Utilities Basic Materials And Methods
33 01 30 11	01 22 16 00	No Specification Required
33 01 30 41	33 01 10 58a	Sewer Line Cleaning
33 01 30 42	21 05 23 00	Piped Utilities Basic Materials And Methods
33 01 30 42	33 01 10 58	Repair And Maintenance Of Imhoff Tanks
33 01 30 42	33 01 10 58a	Sewer Line Cleaning
33 01 30 74	01 22 16 00	No Specification Required

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SECTION 33 01 30 81 - REPAIR AND MAINTENANCE OF SIPHON TANK AND SIPHONS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for the repair and maintenance of sewage treatment plant dosing siphon tanks. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Tank Repair Material shall be epoxy type grout complying with Fed. Spec. MMM-A-001993.

B. Concrete Coatings:
1. Outside and Above Grade shall be epoxy type in compliance with Mil. Spec. MIL-P-24441.
2. Inside and Below Grade shall be coal-tar epoxy type in compliance with SSPC-PAINT 16.

C. Steel Repair Material shall be steel plate or epoxy cement and fiberglass cloth.

D. Corroded or Defective Siphons: Replace those parts corroded or defective with new parts compatible with the unit, as recommended by the manufacturer.

E. Steel Coatings:
1. Red-Lead Base Coat shall comply with Fed. Spec. TT-P-86, Type I.
2. Aluminum Paint shall comply with Fed. Spec. TT-P-38.

1.3 EXECUTION

A. Corroded or Broken Pipe and Fittings: Replace as required.

B. Minor Leaks: Repair minor leaks in the tank using material and surface preparation and application methods recommended by the material manufacturer.

C. Spalled Areas: Repair as required.

D. Cleaning and Coating:
1. Interior Concrete Surfaces of the tank shall be cleaned with high pressure water or steam to remove all dirt and residue, allowed to dry, and brush sandblasted in compliance with SSPC-SP 7.
2. The Exterior Concrete Surfaces of the tank shall be cleaned by means of brush sandblasting in compliance with SSPC-SP 7. The surfaces shall be blown down with air to remove the blasting residue and dust, and two coats of epoxy-polyamide paint shall be applied.
3. Holes and Voids in the concrete surfaces left from the blast cleaning shall be filled by means of troweling and squeeze application of an epoxy filler. The surfacing material shall be allowed to cure overnight, and then two coats of coal-tar epoxy complying with SSPC-PAINT 16 shall be applied.

4. Submerged Ferrous Metal Surfaces that are exposed to the sewage shall be sandblasted in compliance with SSPC-SP 10 and coated with two coats of coal-tar epoxy.
5. Ferrous Metal Surfaces that are not submerged shall be cleaned by means of sandblasting in compliance with SSPC-SP 6. Surfaces inaccessible to sandblasting shall be power tool cleaned in compliance with SSPC-SP 3. Surfaces shall be coated with one coat of red-lead base paint. After the base paint has dried sufficiently, two coats of aluminum finish paint shall be applied.

END OF SECTION 33 01 30 81

SECTION 33 01 30 81a - UNDERGROUND DUCTS AND UTILITY STRUCTURES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for underground ducts and utility structures. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Conduit, ducts, and duct accessories for direct-buried and concrete-encased duct banks, and in single duct runs\.
b. Handholes and pull boxes.
c. Manholes.

C. Definition
1. RNC: Rigid nonmetallic conduit.

D. Submittals
1. Product Data: For the following:
a. Duct-bank materials, including separators and miscellaneous components.
b. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
c. Accessories for manholes, handholes, pull boxes, and other utility structures.
d. Warning tape.
e. Warning planks.
2. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:
a. Duct entry provisions, including locations and duct sizes.
b. Reinforcement details.
c. Frame and cover design and manhole frame support rings.
d. Ladder **OR** Step, **as directed,** details.
e. Grounding details.
f. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
g. Joint details.
3. Shop Drawings for Factory-Fabricated Handholes and Pull Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:
a. Duct entry provisions, including locations and duct sizes.
b. Cover design.
c. Grounding details.
d. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
4. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
a. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
b. Drawings shall be signed and sealed by a qualified professional engineer.
5. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.
6. Qualification Data: For qualified professional engineer and testing agency.
7. Source quality-control reports
8. Field quality-control test reports.

E. Quality Assurance
1. Comply with IEEE C2.
2. Comply with NFPA 70.

F. Delivery, Storage, And Handling
1. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.
2. Store precast concrete and other factory-fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.
3. Lift and support precast concrete units only at designated lifting or supporting points.

G. Project Conditions
1. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   a. Notify the Owner no fewer than two days in advance of proposed interruption of electrical service.
   b. Do not proceed with interruption of electrical service without the Owner's written permission.

1.2 PRODUCTS

A. Conduit
1. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.
2. RNC: NEMA TC 2, Type EPC-40-PVC and Type EPC-80-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

B. Nonmetallic Ducts And Duct Accessories
1. Underground Plastic Utilities Duct: NEMA TC 6 & 8, Type EB-20-PVC, ASTM F 512, UL 651A, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.
2. Underground Plastic Utilities Duct: NEMA TC 6 & 8, Type DB-60-PVC and Type DB-120-PVC, ASTM F 512, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.
3. Duct Accessories:
   a. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
   b. Warning Tape: Underground-line warning tape specified in Division 26 Section "Identification For Electrical Systems".
   c. Concrete Warning Planks: Nominal 12 by 24 by 3 inches (300 by 600 by 76 mm) in size, manufactured from 6000-psi (41-MPa) concrete.
      1) Color: Red dye added to concrete during batching.
      2) Mark each plank with "ELECTRIC" in 2-inch- (50-mm-) high, 3/8-inch- (10-mm-) deep letters.

C. Precast Concrete Handholes And Pull Boxes
1. Comply with ASTM C 858 for design and manufacturing processes.
2. Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A153 (ASTM A153M) and ASTM A123 (ASTM A123M).
3. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or pull box.

a. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
b. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
c. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.
   1) Cover Hinges: Concealed, with hold-open ratchet assembly.
   2) Cover Handle: Recessed.
d. Frame and Cover: Weatherproof aluminum frame with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing stainless-steel bolts.
   1) Cover Hinges: Concealed, with hold-open ratchet assembly.
   2) Cover Handle: Recessed.
e. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
f. Cover Legend: Molded lettering, "ELECTRIC" **OR** "TELEPHONE" **OR** As indicated for each service, **as directed**.
g. Configuration: Units shall be designed for flush burial and have open **OR** closed **OR** integral closed, **as directed,** bottom, unless otherwise indicated.
h. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
   1) Extension shall provide increased depth of 12 inches (300 mm).
   2) Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.
i. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.
   1) Windows shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
   2) Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
   3) Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
j. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
   1) Type and size shall match fittings to duct or conduit to be terminated.
   2) Fittings shall align with elevations of approaching ducts and be located near interior corners of handholes to facilitate racking of cable.
k. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

D. Handholes and Pull Boxes Other Than Precast Concrete
1. Description: Comply with SCTE 77.
   a. Color: Gray **OR** Green, **as directed**.
   b. Configuration: Units shall be designed for flush burial and have open **OR** closed **OR** integral closed, **as directed,** bottom, unless otherwise indicated.
   c. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
   d. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
   e. Cover Legend: Molded lettering, "ELECTRIC" **OR** "TELEPHONE" **OR** As indicated for each service, **as directed**.
   f. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
   g. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
   h. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2. Polymer Concrete Handholes and Pull Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
3. Fiberglass Handholes and Pull Boxes with Polymer Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.
4. Fiberglass Handholes and Pull Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete **OR** reinforced concrete **OR** cast iron **OR** hot-dip galvanized-steel diamond plate **OR** fiberglass, **as directed**.
5. High-Density Plastic Pull Boxes: Injection molded of high-density polyethylene or copolymer-polypropylene. Cover shall be polymer concrete **OR** hot-dip galvanized-steel diamond plate **OR** plastic, **as directed**.

E. Precast Manholes
1. Comply with ASTM C 858, with structural design loading as specified in Para. 1.3 "Underground Enclosure Application" Article and with interlocking mating sections, complete with accessories, hardware, and features.
   a. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.
      1) Windows shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
      2) Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
      3) Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
   b. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
      1) Type and size shall match fittings to duct or conduit to be terminated.
      2) Fittings shall align with elevations of approaching ducts and be located near interior corners of manholes to facilitate racking of cable.
2. Concrete Knockout Panels: 1-1/2 to 2 inches (38 to 50 mm) thick, for future conduit entrance and sleeve for ground rod.
3. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

F. Cast-In-Place Manholes
1. Description: Underground utility structures, constructed in place, complete with accessories, hardware, and features. Include concrete knockout panels for conduit entrance and sleeve for ground rod.
2. Materials: Comply with ASTM C 858 and with Division 03 Section "Cast-in-place Concrete".
   a. Concrete shall have a minimum compressive strength of 3000 psi (20 MPa).
3. Structural Design Loading: As specified in "Underground Enclosure Application" Article.

G. Utility Structure Accessories
1. Ferrous metal hardware, where indicated, shall be hot-dip galvanized complying with ASTM A 153 (A 153M) and A 123 (A 123M).
2. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.
   a. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B **OR** cast aluminum, **as directed,** with milled cover-to-frame bearing surfaces; diameter, 26 inches (660 mm) **OR** 29 inches (737 mm), **as directed**.
      1) Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

2) Special Covers: Recess in face of cover designed to accept finish material in paved areas.

b. Cover Legend: Cast in. Selected to suit system.
1) Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
2) Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.
3) Legend: "SIGNAL" for communications, data, and telephone duct systems.

c. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
1) Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. (60 L) where packaged mix complying with ASTM C 387, Type M, may be used.

3. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.
4. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch- (50-mm-) diameter eye, and 1-by-4-inch (25-by-100-mm) bolt.
a. Working Load Embedded in 6-Inch (150-mm), 4000-psi (27.6-MPa) Concrete: 13,000-lbf (58-kN) minimum tension.
5. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch- (32-mm-) diameter eye, rated 2500-lbf (11-kN) minimum tension.
6. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch- (22-mm-) diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
a. Ultimate Yield Strength: 40,000-lbf (180-kN) shear and 60,000-lbf (270-kN) tension.
7. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch (13-mm) ID by 2-3/4 inches (69 mm) deep, flared to 1-1/4 inches (32 mm) minimum at base.
a. Tested Ultimate Pullout Strength: 12,000 lbf (53 kN) minimum.
8. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch (13-mm) bolt, 5300-lbf (24-kN) rated pullout strength, and minimum 6800-lbf (30-kN) rated shear strength.
9. Cable Rack Assembly: Steel, hot-rolled **OR** hot-dip, **as directed,** galvanized, except insulators.
a. Stanchions: T-section or channel; 2-1/4-inch (57-mm) nominal size; punched with 14 holes on 1-1/2-inch (38-mm) centers for cable-arm attachment.
b. Arms: 1-1/2 inches (38 mm) wide, lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 18 inches (460 mm) with 250-lb (114-kg) minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
c. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.
10. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.
a. Stanchions: Nominal 36 inches (900 mm) high by 4 inches (100 mm) wide, with minimum of 9 holes for arm attachment.
b. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 20 inches (508 mm) with 250-lb (114-kg) minimum capacity. Top of arm shall be nominally 4 inches (100 mm) wide, and arm shall have slots along full length for cable ties.
11. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F (2 deg C). Capable of withstanding temperature of 300 deg F (150 deg C) without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.
12. Fixed Manhole Ladders: Arranged for attachment to roof or wall **OR** and floor, **as directed,** of manhole. Ladder and mounting brackets and braces shall be fabricated from nonconductive, structural-grade, fiberglass-reinforced resin **OR** hot-dip galvanized steel, **as directed**.

13. Portable Manhole Ladders: UL-listed, heavy-duty wood **OR** fiberglass, **as directed,** specifically designed for portable use for access to electrical manholes. Minimum length equal to distance from deepest manhole floor to grade plus 36 inches (900 mm). One required.
14. Cover Hooks: Heavy duty, designed for lifts 60 lbf (270 N) and greater **OR** Light duty, designed for lifts less than 60 lbf (270 N), **as directed**. Two required.

H. Source Quality Control
1. Test and inspect precast concrete utility structures according to ASTM C 1037.
2. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and pull boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
   a. Engage a qualified testing agency to evaluate nonconcrete handholes and pull boxes.
   b. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

1.3 EXECUTION

A. Corrosion Protection
1. Aluminum shall not be installed in contact with earth or concrete.

B. Underground Duct Application
1. Ducts for Electrical Cables Over 600 V: RNC, NEMA Type EPC-80 **OR** EPC-40 **OR** EB-20, **as directed,**-PVC, in concrete-encased duct bank, unless otherwise indicated.
2. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-80 **OR** EPC-40 **OR** EB-20, **as directed,**-PVC, in concrete-encased duct bank, unless otherwise indicated.
3. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-80 **OR** EPC-40 **as directed,**-PVC, in direct-buried duct bank, unless otherwise indicated.
4. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-80 **OR** EPC-40, **as directed,**-PVC, in direct-buried duct bank, unless otherwise indicated.
5. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40 **OR** EB-20, **as directed,**-PVC, in concrete-encased duct bank, unless otherwise indicated.
6. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40-PVC **OR** Underground plastic utilities duct, NEMA Type DB-60-PVC **OR** Underground plastic utilities duct, NEMA Type DB-120-PVC, **as directed,** installed in direct-buried **OR** concrete-encased, **as directed,** duct bank, unless otherwise indicated.
7. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type EPC-40 **OR** DB-60 **OR** DB-120, **as directed,**-PVC, in direct-buried duct bank, unless otherwise indicated.
8. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type EB-20-PVC, in concrete-encased duct bank, unless otherwise indicated.
9. Underground Ducts Crossing Paved Paths **OR** Walks and Driveways **OR** Roadways and Railroads, **as directed**: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

C. Underground Enclosure Application
1. Handholes and Pull Boxes for 600 V and Less, Including Telephone, Communications, and Data Wiring:
   a. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-10 **OR** H-20, **as directed,** structural load rating.
   b. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 **OR** Polymer concrete, SCTE 77, Tier 15 **OR** Fiberglass enclosures with polymer concrete frame and cover, SCTE 77, Tier 15 **OR** Fiberglass-reinforced polyester resin, SCTE 77, Tier 15 **OR** High-density plastic, SCTE 77, Tier 15, **as directed,** structural load rating.

c. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10 **OR** Polymer concrete units, SCTE 77, Tier 8 **OR** Heavy-duty fiberglass units with polymer concrete frame and cover, SCTE 77, Tier 8 **OR** High-density plastic, SCTE 77, Tier 8, **as directed,** structural load rating.

d. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin **OR** High-density plastic, **as directed**, structurally tested according to SCTE 77 with 3000-lbf (13 345-N) vertical loading.

2. Manholes: Precast or cast-in-place concrete.
   a. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
   b. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

D. Earthwork
1. Excavation and Backfill: Comply with Division 31 Section "Earth Moving", but do not use heavy-duty, hydraulic-operated, compaction equipment.
2. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
3. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Division 32 Section(s) "Turf And Grasses" AND "Plants".
4. Cut and patch existing pavement in the path of underground ducts and utility structures according to Division 01 Section "Cutting And Patching".

E. Duct Installation
1. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.
2. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches (1220 mm) **OR** 12.5 feet (4 m) **OR** 25 feet (7.5 m), **as directed**, both horizontally and vertically, at other locations, unless otherwise indicated.
3. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.
4. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches (250 mm) o.c. for 5-inch (125-mm) ducts, and vary proportionately for other duct sizes.
   a. Begin change from regular spacing to end-bell spacing 10 feet (3 m) from the end bell without reducing duct line slope and without forming a trap in the line.
   b. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole.
   c. Grout end bells into structure walls from both sides to provide watertight entrances.
5. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet (3 m) outside the building wall without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Division 26 Section "Common Work Results For Electrical".
6. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.
7. Pulling Cord: Install 100-lbf- (445-N-) test nylon cord in ducts, including spares.
8. Concrete-Encased Ducts: Support ducts on duct separators.
   a. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 4 **OR** 5, **as directed,** spacers per 20 feet (6 m) of duct. Secure

separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches (150 mm) between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.

b. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
   1) Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.
   2) If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch (19-mm) reinforcing rod dowels extending 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.

c. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.

d. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.

e. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.

f. Minimum Space between Ducts: 3 inches (75 mm) between ducts and exterior envelope wall, 2 inches (50 mm) between ducts for like services, and 4 inches (100 mm) between power and signal ducts.

g. Depth: Install top of duct bank at least 24 inches (600 mm) below finished grade in areas not subject to deliberate traffic, and at least 30 inches (750 mm) below finished grade in deliberate traffic paths for vehicles, unless otherwise indicated.

h. Stub-Ups:
   1) Use manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Extend concrete encasement throughout the length of the elbow.

      OR

      Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
      a) Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
      b) Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of base. Install insulated grounding bushings on terminations at equipment.

i. Warning Tape: Bury warning tape approximately 12 inches (300 mm) above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches (75 mm) of the centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.

9. Direct-Buried Duct Banks:
   a. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
   b. Space separators close enough to prevent sagging and deforming of ducts, with not less than 4 **OR** 5, **as directed,** spacers per 20 feet (6 m) of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement

due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches (150 mm) between tiers.

c. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Division 31 Section "Earth Moving" for pipes less than 6 inches (150 mm) in nominal diameter.

d. Install backfill as specified in Division 31 Section "Earth Moving".

e. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches (100 mm) over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving".

f. Install ducts with a minimum of 3 inches (75 mm) between ducts for like services and 6 inches (150 mm) between power and signal ducts.

g. Depth: Install top of duct bank at least 36 inches (900 mm) below finished grade, unless otherwise indicated.

h. Set elevation of bottom of duct bank below the frost line.

i. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.

OR

Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

1) Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.

2) For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

j. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried ducts and duct banks, placing them 24 inches (600 mm) o.c. Align planks along the width and along the centerline of duct bank. Provide an additional plank for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional planks 12 inches (300 mm) apart, horizontally.

F. Installation Of Concrete Manholes, Handholes, And Pull Boxes

1. Cast-in-Place Manhole Installation:

a. Finish interior surfaces with a smooth-troweled finish.

b. Windows for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inches (38 to 50 mm) thick, arranged as indicated.

c. Cast-in-place concrete, formwork, and reinforcement are specified in Division 03 Section "Cast-in-place Concrete".

2. Precast Concrete Handhole and Manhole Installation:

a. Comply with ASTM C 891, unless otherwise indicated.

b. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.

c. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

3. Elevations:

a. Manhole Roof: Install with rooftop at least 15 inches (380 mm) below finished grade.

b. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch (25 mm) above finished grade.

c. Install handholes with bottom below the frost line, below grade.

d. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
e. Where indicated, cast handhole cover frame integrally with handhole structure.

4. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.
5. Manhole Access: Circular opening in manhole roof; sized to match cover size.
   a. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
   b. Install chimney, constructed of precast concrete collars and rings to support frame and cover and to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney.
6. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Division 07 Section(s) "Elastomeric Sheet Waterproofing" OR "Thermoplastic Sheet Waterproofing", **as directed.** After ducts have been connected and grouted, and before backfilling, waterproof joints and connections and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.
7. Dampproofing: Apply dampproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Division 07 Section "Bituminous Dampproofing". After ducts have been connected and grouted, and before backfilling, dampproof joints and connections and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.
8. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.
9. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
10. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches (98 mm) for manholes and 2 inches (50 mm) for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.
11. Warning Sign: Install "Confined Space Hazard" warning sign on the inside surface of each manhole cover.

G. Installation Of Handholes And Pull Boxes Other Than Precast Concrete

1. Install handholes and pull boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.
2. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.7-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
3. Elevation: In paved areas and trafficways, set so cover surface will be flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
4. Install handholes and pull boxes with bottom below the frost line, below grade.
5. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.
6. Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
7. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
   a. Concrete: 3000 psi (20 kPa), 28-day strength, complying with Division 03 Section "Cast-in-place Concrete", with a troweled finish.

b. Dimensions: 10 inches wide by 12 inches deep (250 mm wide by 300 mm deep).

H. Grounding
1. Ground underground ducts and utility structures according to Division 26 Section "Grounding And Bonding For Electrical Systems".

I. Field Quality Control
1. Perform the following tests and inspections:
   a. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
   b. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
   c. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Division 26 Section "Grounding And Bonding For Electrical Systems".
2. Correct deficiencies and retest as specified above to demonstrate compliance.
3. Prepare test and inspection reports.

J. Cleaning
1. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
2. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION 33 01 30 81a

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Task	Specification	Specification Description
33 01 30 81	01 22 16 00	No Specification Required
33 01 30 81	21 05 23 00	Piped Utilities Basic Materials And Methods
33 01 30 81	22 05 76 00	Sanitary Sewerage
33 01 30 81	33 01 10 58	Repair And Maintenance Of Imhoff Tanks
33 01 30 81	33 42 11 00	Storm Drainage
33 01 30 81	31 32 19 16	Sewage Treatment Lagoons
33 01 30 82	01 22 16 00	No Specification Required
33 01 30 83	01 22 16 00	No Specification Required
33 01 30 83	21 05 23 00	Piped Utilities Basic Materials And Methods
33 01 30 83	33 01 10 58	Repair And Maintenance Of Imhoff Tanks
33 01 30 83	33 01 30 81	Repair And Maintenance Of Siphon Tank And Siphons
33 01 30 86	01 22 16 00	No Specification Required
33 01 30 86	21 05 23 00	Piped Utilities Basic Materials And Methods
33 01 30 86	33 01 10 58	Repair And Maintenance Of Imhoff Tanks
33 01 30 86	33 01 30 81	Repair And Maintenance Of Siphon Tank And Siphons
33 01 34 13	21 05 23 00	Piped Utilities Basic Materials And Methods
33 01 34 13	33 01 30 81	Repair And Maintenance Of Siphon Tank And Siphons

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SECTION 33 05 07 13 - TRENCHLESS EXCAVATION USING MICROTUNNELING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of trenchless excavation using microtunneling. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Design Requirements
1. Pipe Casing: Provide pipe casing in thickness indicated of polyvinyl chloride (PVC) plastic **OR** clay tile **OR** concrete **OR** steel, **as directed,** pipe. Provide utility line accessories, valves, connections, and manholes as specified and where indicated. Submit design calculations of pipe casing.

C. Submittals: Submit the following:
1. Preconstruction Submittals: Microtunneling Boring Machine equipment to be used.
2. Product Data
   a. Piping casing, joints, fittings, valves, and couplings
   b. Bentonite
   c. Submit manufacturer's standard drawings or catalog cuts, except submit both drawings and cuts for push-on and rubber-gasketed bell-and-spigot joints. Include information concerning gaskets with submittal for joints and couplings.
3. Design Data: Design calculations of pipe casing
4. Certificates
   a. Piping casing piping, fittings, joints, valves, and coupling
   b. Shop-applied linings
   c. Certificates shall attest that tests set forth in each applicable referenced publication have been performed, whether specified in that publication to be mandatory or otherwise and that production control tests have been performed at the intervals or frequency specified in the publication. Other tests shall have been performed within 3 years of the date of submittal or certificates on the same type, class, grade, and size of material as is being provided for the project.
5. Manufacturer's Instructions: Installation procedures for pipe casing

D. Delivery, Storage, and Handling:
1. Inspect materials delivered to site for damage. Unload and store with minimum handling. Store materials on site in enclosures or under protective covering. Store plastic piping, jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes, fittings, and valves free of dirt and debris.
2. Handle pipe, fittings, valves, hydrants, and other accessories in a manner to ensure delivery to the excavation in sound undamaged condition. Take special care to avoid injury to coatings and linings on pipe and fittings; make satisfactory repairs if coatings or linings are damaged. Carry, do not drag pipe to the excavation. Store plastic piping, jointing materials and rubber gaskets that are not to be installed immediately, under cover out of direct sunlight. Handle steel pipe with coal-tar enamel **OR** coal-tar epoxy, **as directed**, coating in accordance with the provisions for handling coal-tar enamel coated pipe in AWWA C203.

E. Quality Assurance
1. Design Calculations of Pipe Casing: Submit design calculations of pipe casing demonstrating that the pipe casing selected has been designed to support the maximum anticipated earth loads and superimposed live loads, both static and dynamic, which may be imposed on the pipe casing.

1.2 PRODUCTS

A. Piping Casing Materials
1. Ductile-Iron Piping
a. Pipe and Fittings: Pipe, except flanged pipe, ANSI/AWWA C151/A21.51 Pressure Class and/or Thickness Class as required to meet Project requirements. The outside diameter of ductile iron microtunneling pipe shall be in accordance with AWWA C150/A21.50.
b. Joints and Jointing Material: Joints: Pressure and gravity microtunneling pipe shall have either an integral-bell push-on or rubber gasket coupled joint meeting the following criteria:
1) Integral-bell push-on joint microtunneling pile shall consist of a rubber-gasket joint manufactured to conform with AWWA C111/A21.11 and the dimensions shown in ANSI/AWWA C151/A21.51. The exterior of the pipe shall be coated with a durable cement-mortar or concrete coating applied in such a manner as to provide a uniform outside diameter.
2) Cement-mortar or concrete strength, reinforcement and method of placement shall be in accordance with manufacturer's recommendations. Durable Coatings of other types may be substituted provided they maintain a uniform outside diameter and they are approved by the designer. Rubber gasket coupled microtunneling joint shall be manufactured so as to provide a joint which has the same nominal outside diameter as the pipe barrel.
2. Polyvinyl Chloride Pipe (PVC): ASTM F 794. ASTM D 3212 for gasketed joint systems. ASTM F 477 for gasket materials.
3. Reinforced Concrete Pipe
a. Nominal dimensions: Typical nominal dimensions for reinforced concrete pipe are detailed in ASTM standards ASTM C 76 (ASTM C 76M), ASTM C 361 (ASTM C361M), ASTM C 655 (ASTM C 655M), ASTM C 822. Pipe meeting these requirements is generally acceptable for jacking. The permissible variation allowed with respect to these and other dimensions shall be in accordance with the variations listed in the section.
b. Joints and Jointing Material: Joint shall be formed entirely of concrete and as detailed in the contract drawings, may **OR** shall, **as directed**, utilize a rubber gasket or mastic to provide the seal. Incorporate an assembly of steel bands or steel bell ends and spigot rings and rubber gaskets in accordance with contract drawings.
4. Steel Pipe
a. Steel pipe shall be in conformance with ASTM A 139, Grade B with a minimum yield strength of 35,000 psi (242 MPa) **OR** AWWA C200 **OR** API SPEC 5L Grade B **OR** ASTM A 53 **OR** ASTM A 716 **OR** ASTM A 746, **as directed**. Steel pipe shall be welded, seamless, square cut with even lengths and shall comply of Articles 4.2, 4.3, and 4.4 of the API SPEC 5L.
b. Joints: The connection of adjacent pieces of microtunneling steel pipe may be accomplished by field buttwelding, internal weld sleeves, integral press fit connectors, as long as loading and installation design criteria are met.
5. Fiberglass Pipe
a. Pipe: Fiberglass pipe shall meet the requirements of ASTM D 3262, Type 1, Liner 2, Grade 3. The method of the manufacture shall be centrifugal casting resulting in a controlled outside diameter. Minimum wall thickness shall be +1.5 inches (+38 mm).
b. Joints: The pipes shall be connected by gasket-sealed bell-spigot joints. The gasket material shall meet requirements of ASTM F 477. The joint shall meet the requirements of ASTM D 4161 and shall be leak-free under the following conditions:
1) External pressures up to 2 bars, 29 psi (200 kPa) from bentonite injection, slurry system operation or groundwater head.
2) Internal air testing up to 5 psi (35 kPa).
3) Gaps between the pipe ends up to two percent of the diameter (maximum of 1-inch (25 mm)).

c. The liner shall consist of a minimum thickness of 0.04 inch (1.2 mm) of reinforced polyester resin. The outside pipe coating shall have a minimum thickness of 0.03 inches (one mm) and shall consist of thermosetting polyester resin and sand.

6. Vitrified Clay Pipe: ASTM C 700.
   a. Pipe: Vitrified clay pipe shall be manufactured from fire clay, shale, surface clay, or a combination that can meet three edge bearing strength for nominal diameters ranging from 4 inches 2000 lb/linear foot (100 mm 2980 kg/m) to 42 inches 7000 lb/linear foot (1050 mm 10430 kg/m).
   b. Joints: Joints shall be capable of supporting a shear load of 50 pounds per inch (8755 N/m) of nominal diameter uniformly applied over an arc of not less than 120 degrees (2.09 rad) and along a distance of 12 inches (300 mm) adjacent to the joint. Apply an internal 10 foot (3 m) head 4.3 psi (30 kPa) of water pressure for a period of one hour. Joints shall fully comply with ASTM C 1208 (ASTM C 1208M).
7. Concrete: Concrete shall be 3000 psi (25 MPa) and conform with Division 03 Section "Cast-in-place Concrete".
8. Bentonite: Bentonite shall conform with API SPEC 13A and have the capacity of mixing with water to form a stable and homogeneous suspension.
9. Backfill: Reuse excavated sand for backfill that conforms with Division 31 Section "Earth Moving".

1.3 EXECUTION

A. Preparation
1. Access Shafts
   a. Construction methods required to provide access shafts for microtunneling shall be subject to approval of the Owner. Acceptable construction methods may include the use of interlocked steel sheet piling or precast circular concrete segments lowered in place during excavation.
   b. Final dimensions of access shafts selected by the Contractor shall be modified as required following installation of pipe casings to the size and shape of acceptable manhole designs shown on the Contract Drawings to permit installation of conveyance piping.
   c. Shafts shall be of a size commensurate with safe working practices and located as shown on plans. With the approval of the Owner, the Contractor may relocate shafts to better suit the capabilities of the microtunneling method proposed. Where no locations are given, the Contractor shall determine suchfficer.
   d. Shaft locations shall, where possible, be kept clear of road intersections and within a single traffic lane, in order to minimize disruption to the flow of traffic. Support equipment, spoil piles, and materials shall also be located such as to minimize disruption to traffic and are subject to the approval of the Owner.
   e. The Contractor shall properly support all excavations and prevent movement of the soil, pavement, utilities or structures outside of the excavation. The Contractor shall furnish, place and maintain sheeting, bracing, and lining required to support the sides and floor of all pits and to provide adequate protection of the work, personnel, and the general public. Design loads on the sides of the jacking and receiving pit walls are dependent on the construction method and flexibility of the wall systems.
   f. Construct a starter shaft to accommodate the installation of pipe casings, slurry shield and piping jacking device. Install thrust block as required and consolidate the ground (grout) where the casings exit the shaft.
   g. Construct a receiver shaft to accommodate the installation of pipe casings and the slurry shield. Consolidate the ground (grout) where the casings enter the shaft.
   h. The Contractor shall furnish, install, and maintain equipment to keep the jacking shaft free of excess water. The Contractor shall also provide surface protection during the period of construction to ensure that surface runoff does not enter driving shaft(s). Groundwater dewatering shall comply with the approved dewatering plan and shall not affect

surrounding soils or structures beyond the tolerances stated in paragraph entitled "Settlement, Alignment and Tolerances."

i. Provide security fence around all access shaft areas and provide shaft cover(s) when the shaft area is not in use.

j. Design of the jacking and receiving pit supports should also take into account the loading from shield or pipe jacking where appropriate, as well as special provisions and reinforcement around the breakout location. The base of the pits shall be designed to withstand uplift forces from the full design head of water, unless approved dewatering or other ground modification methods are employed.

k. Where a thrust block is required to transfer jacking loads into the soil, it shall be properly designed and constructed by the Contractor. The backstop shall be normal (square) with the proposed pipe alignment and shall be designed to withstand the maximum jacking pressure to be used with a factor of safety of at least 2.0. It shall also be designed to minimize excessive deflections in such a manner as to avoid disturbance of adjacent structures or utilities or excessive ground movement. If a concrete thrust block or treated soil zone is utilized to transfer jacking loads into the soil, the tunnel boring is not to be jacked until the concrete or other materials have attained the required strength.

l. Pit Backfill and Compaction: Upon completion of the pipe drive and approval of the installed pipeline by the Owner, remove all equipment, debris, and unacceptable materials from the pits and commence backfilling operation. Backfilling, compaction and pavement repairs shall be completed in accordance with Division 31 Section "Earth Moving".

m. If tremie concrete sealing slabs are placed within the earth support system to prevent groundwater inflow when access shafts are dewatered, the sealing slabs shall be of sufficient thickness to provide a factor of safety equal to 1.2 against hydrostatic uplift in order to prevent bottom blowout when the excavation is completely dewatered.

B. Installation

1. Installation of Tracer Wire: Install a continuous length of tracer wire for the full length of each run of nonmetallic pipe. Attach wire to top of pipe in such a manner that will not be displaced during construction operations.
2. Connections to Existing Lines: Make connections to existing lines after the Owner approval is obtained and with a minimum interruption of service on the existing line. Make connections to existing lines under pressure in accordance with the recommended procedures of the manufacturer of the pipe being tapped.
3. Minimum depth of cover over the pipe being installed shall be 6 feet (1.8 m) or 1.5 times the outer diameter of the pipe being installed.
4. Settlement, Alignment and Tolerances
   a. Settlement or heave of ground surface along centerline of microtunneling alignments during and after installation of pipe casings shall not exceed 1 inch (25 mm).
   b. No more than 1 inch (25 mm) lateral and 1 inch (25 mm) vertical deviation shall be permitted in the position of the completed jacked pipe casings. Water shall be free draining between any two points at the pipe invert. No reverse grades will be allowed.
   c. Overcut shall not exceed 1 inch (25 mm) on the radius of the pipe being installed. The annular space created by the overcut must be filled with the lubrication material that is used to reduce soil friction drag on the pipe.
5. Microtunneling
   a. Using Unmanned Tunneling Machine
      1) The microtunneling boring machine shall be an unmanned mechanical type earth pressure counter-balanced bentonite slurry shield system. The machine shall be laser guided and monitored continuously, with a closed circuit television system. The machine shall be capable of fully supporting the face both during excavation and during shutdown and shall have the capability, of positively measuring the earth pressure at the face. Excavation face pressure shall be maintained at all times between the measured active earth pressure and 50 percent of the computed passive earth pressure. Fluid pressure applied at the face to stabilize the

excavation shall be maintained at a level slightly in excess of normal hydrostatic pressure and shall be monitored continuously. The machine shall be operated so as to prevent either surface heave or loss of ground during tunneling and shall be steerable and capable of controlling the advance of the heading to maintain line and grade within the tolerances specified in paragraph entitled "Settlement, Alignment and Tolerances." The machine shall be capable of handling and removing materials of high water content from the machine head.

2) Each pipe casing section shall be jacked forward as the excavation progresses in such a way to provide complete and adequate, ground support at all times. A bentonite slurry (driller's mud) shall be applied to the external surface of the pipe to reduce skin friction. A jacking frame shall be provided for developing a uniform distribution of jacking forces around the periphery of the pipe. A plywood spacer shall be placed on the outer shoulder of the pipe casing joint. The thrust reaction backstop shall be properly designed and constructed.

3) The backstop shall be normal (square) with the proposed pipe casing alignment and shall be designed to support the maximum obtainable jacking pressure with a safety factor at least 2.0.

4) The jacking system shall be capable of continuously monitoring the jacking pressure and rate of advancement. Special care shall be taken when setting the pipe guard rails in the starter shaft to ensure correctness of the alignment, grade and stability.

b. Using Tunneling Shields

1) Only tunneling equipment capable of fully supporting the face of the tunnel shall be used for pipe jacking work described.

2) Tunneling equipment selected for the project shall be compatible with the geotechnical information contained in this contract. The tunneling equipment shall be capable of tunneling through mixed face conditions without exceeding the settlement tolerances specified in paragraph "Settlement, Alignment and Tolerances."

3) Face pressure exerted at the heading by the tunneling machine shall be maintained as required to prevent loss of ground, groundwater inflows, and settlement or heave of the ground surface by balancing soils and groundwater pressures present.

4) Dewatering for groundwater control shall be allowed at the jacking and receiving pits only.

c. Do not jack pipe casing until the concrete thrust block and tremie seal (if selected), and grouted soil zone in starter and receiving shafts have attained the required strength.

d. The pipe casing shall be jacked in place without damaging the pipe casing joints or completed pipe casing section.

e. After completion of the jacking operation between starter and receiver shafts, the lubricate material shall be displaced from between the pipe casing exterior and the surrounding ground by a cement grout. Pressure and the amount of grout shall be controlled to avoid pipe damage and displacement of the pipe and soil beyond the tolerances specified in paragraph "Settlement, Alignment and Tolerances." Grouting shall be accomplished promptly after pipe installation has been completed to prevent any surface settlement due to movement of soil material into the void space or loosened zone around the pipe casing.

f. Any pipe casing which has been damaged during installation shall be replaced by the Contractor at no additional cost. If a new replacement pipe casing is required extending from the starter to the receiver shaft, it shall be installed in conformance with the contract drawings and this section.

g. Steel pipe casing joints shall be continuously welded with butt joint per AWS D1.1. The welds shall attain the full strength of the pipe and shall result in a full watertight section. The inner face of internal weld seam shall be flush with the pipe to facilitate the installation of the conveyance pipe in the pipe casing.

h. Perform all welding in accordance with requirements for shielded metal arc welding of AWS D1.5 for bridges and AWS D1.1 for buildings and other structures.

i. Fiberglass pipe casing joints shall be fully watertight and shall attain the full strength of the pipe. Casing joints shall be field connected with sleeve couplings or bell and spigot type

joints that utilize elastomeric sealing gaskets as the sole means to maintain joint water tightness.

j. The joint shall have the same outside diameter as the pipe so when the pipelines are assembled such that the joints are flush with the pipe inside and outside surface to facilitate installation of it conveyance pipe in the pipe casing.

k. All excavated material from tunnel and shaft construction shall be disposed of away from the construction site. On-site storage of material must comply with Division 01 requirements and must be stored in areas shown on site drawings or as directed. Stockpiling shall be permitted on the construction site and material shall be removed at regular intervals as directed by the Owner.

l. Monitor ground movements associated with the project and make suitable changes in the construction methods that control ground movements and prevent damage or detrimental movement to the work and adjacent structures and pavements.

m. Install instrumentation, take readings and provide the Owner with weekly reports containing measurements data with weekly reports to inspector. These actions are meant to supplement the Contractor's monitoring system and do not relieve the Contractor of its responsibility, nor place on the Owner, responsibility for control of ground movement and protection of the project and adjacent structures. Instrumentation readings shall be continued for a period of time as directed by the Owner after pipe casings have been installed to establish that detrimental settlement has not occurred.

n. Unprotected mining of the tunnel bore is not permitted. The tunnel face and bore shall be fully supported at all times.

o. A topographic survey will be performed by the Contractor before and after microtunneling and at intervals as directed by the Owner. Survey markers will be installed by the contractor at grid points located as directed by the Owner centered on the proposed tunnel alignments. Perform all remedial work including repaired if heave or settlement greater than 1 inch (25 mm) is recorded.

p. Approval by the Owner of the topographic survey and final set of readings provided by the Contractor will constitute partial approval of the microtunneling phase of work.

6. Ventilation: Adequate ventilation shall be provided for all cased tunnels and shafts. Follow confined space entry procedures. Local burn permit regulations must be obeyed and complied with. The design of ventilating system shall include such factors as the volume required to furnish fresh air in the shafts, and the volume to remove dust that may be caused by the cutting of the face and other operations which may impact the laser guidance system.

7. Lighting: Adequate lighting shall be provided for the nature of the activity being conducted by workers for the microtunneling. Both power and lighting circuits shall be separated and thoroughly insulated with ground fault interrupters are required. Lights shall comply with requirements with regards to shatter resistance and illumination requirements.

8. Spoil Transportation: The soil transportation system shall match the excavation rate with rate of spoil removal. The system must also be capable of balancing groundwater pressures and adjustment to maintain face stability for the particular soil conditions of this project.

9. Pipe Jacking Equipment: The main jacking equipment installed must have a capacity greater than the anticipated jacking load. Intermediate jacking stations shall be provided by the Contractor when the total anticipated jacking force needed to complete the installation may exceed the capacity of the main jacks or the designed maximum jacking force for the pipe. The jacking system shall develop a uniform distribution of jacking forces on the end of the pipe by use of thruster rings and cushioning material.

10. Jacking Pipe: In general, pipe used for jacking shall be smooth, round, have an even outer surface, and joints that allow for easy connections between pipes. Pipe ends shall be square and smooth so that jacking loads are minimized when the pipe is jacking. Pipe used for pipe jacking shall be capable of withstanding the jacking forces that will be imposed by the process or installation, as well as the final place loading conditions. The driving ends of the pipe and intermediate joints shall be protected from damage.

a. Any pipe showing signs of failure may be jacked through to the receiving shaft and removed. Other methods of repairing the damaged pipe may be used, as recommended by the manufacturer and subject to approval by the Owner.
b. The pipe manufacturer's design jacking loads shall not be exceeded during the installation process. The pipe shall be designed to take full account of all temporary installation loads.

C. Field Quality Control
1. Field Tests and Inspections: The Contractor shall perform field tests, and provide labor, equipment, and incidentals required for testing. The Contractor shall product evidence, when required, that any item of work has been constructed in accordance with drawings and specifications.
2. Testing Requirements: For pressure test, use a hydrostatic pressure 50 percent greater than the maximum working pressure of the system. Hold this pressure for not less than 2 hours. For leakage test, use a hydrostatic pressure not less than the maximum working pressure of the system. Leakage test may be performed at the same time and at the same test pressure as the pressure test.

END OF SECTION 33 05 07 13

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Task	Specification	Specification Description
33 05 07 23	01 22 16 00	No Specification Required
33 05 07 23	33 05 07 13	Trenchless Excavation Using Microtunneling
33 05 07 24	33 05 07 13	Trenchless Excavation Using Microtunneling
33 05 61 00	22 05 76 00	Sanitary Sewerage
33 05 61 00	33 42 11 00	Storm Drainage
33 05 63 00	33 01 30 81a	Underground Ducts And Utility Structures
33 05 81 00	01 22 16 00	No Specification Required
33 05 81 00	22 05 76 00	Sanitary Sewerage
33 05 81 00	33 01 30 81a	Underground Ducts And Utility Structures
33 05 81 00	33 42 11 00	Storm Drainage
33 05 81 00	31 32 19 16	Sewage Treatment Lagoons
33 05 83 00	22 05 76 00	Sanitary Sewerage
33 05 83 00	33 01 30 81a	Underground Ducts And Utility Structures
33 05 83 00	33 42 11 00	Storm Drainage
33 05 83 00	31 32 19 16	Sewage Treatment Lagoons
33 05 84 00	01 22 16 00	No Specification Required
33 05 84 00	21 05 23 00	Piped Utilities Basic Materials And Methods
33 05 84 00	22 05 76 00	Sanitary Sewerage
33 05 84 00	33 42 11 00	Storm Drainage
33 05 84 00	31 32 19 16	Sewage Treatment Lagoons

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SECTION 33 11 13 00 - WELL REPAIR

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for repair and maintenance of water wells. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Repair and Replacement Parts shall be clean, free of rust and scale, and of proper size and design for the specific well repair to be made.

1.3 EXECUTION

A. Cement Grout may be hand mixed at the site.

B. Level and Re-Sod Area, after heavy equipment has been used or if chemicals have been spilled.

C. Abandoned Wells shall be sealed in accordance with AWWA A100.

D. Disinfect well, after repair, in accordance with AWWA A100.

END OF SECTION 33 11 13 00

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Task	Specification	Specification Description
33 11 13 00	01 22 16 00	No Specification Required
33 11 13 00	21 05 23 00	Piped Utilities Basic Materials And Methods
33 11 13 00	23 11 23 00a	Monitoring Wells
33 11 13 00	22 11 23 23	Water Supply Wells
33 14 00 00	13 12 13 00	Water Distribution
33 14 11 00	13 12 13 00	Water Distribution
33 14 13 00	13 12 13 00	Water Distribution
33 14 13 13	01 22 16 00	No Specification Required
33 14 13 13	21 05 23 00	Piped Utilities Basic Materials And Methods
33 14 13 13	31 62 16 19	Concrete-Filled Steel Piles
33 14 13 13	13 12 13 00	Water Distribution
33 14 13 13	22 05 76 00	Sanitary Sewerage
33 14 13 13	33 42 11 00	Storm Drainage

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SECTION 33 14 13 23 - SAND DRAINS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of sand drains. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Galvanized Perforated Corrugated Metal Pipe: AASHTO M36.

B. Perforated Polyvinyl Chloride (PVC) Plastic Pipe: ASTM D 1784.

C. Aggregate shall be sand, gravel, crushed rock, or chat that is clean, sound, and of a good quality. Gradation shall conform to the following table:
Retained on the 1-inch sieve 0%
Retained on the 3/8-inch sieve 0-15%
Retained on the No. 8 sieve 40-60%
Retained on the No. 30 sieve 70-95%
Retained on the No. 100 sieve 98-100%

1.3 EXECUTION

A. Pipe Bedding: Aggregate shall be placed in uniform layers on level excavation.

B. Perforated Pipe shall be installed with securely aligned joints to lines and grades, which will allow proper drainage.

C. Perforated Pipe shall be embedded with a minimum coverage of two feet of aggregate or as directed.

END OF SECTION 33 14 13 23

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SECTION 33 14 13 23a - HYDRONIC DISTRIBUTION

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for hydronic distribution. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes underground piping outside the building for distribution of heating hot and chilled water.

C. Performance Requirements
1. Provide components and installation capable of producing hydronic piping systems with the following minimum working-pressure ratings:
   a. Hot-Water Piping: 100 psig (690 kPa) **OR** 150 psig (1035 kPa), **as directed**.
   b. Chilled-Water Piping: 100 psig (690 kPa) **OR** 150 psig (1035 kPa), **as directed**.
   c. Condenser-Water Piping: 100 psig (690 kPa) **OR** 150 psig (1035 kPa), **as directed**.

D. Submittals
1. Product Data
2. Shop Drawings
3. Welding certificates.
4. Source quality-control test reports.
5. Field quality-control test reports.

E. Quality Assurance
1. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.
2. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

F. Project Conditions
1. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
   a. Notify the Owner no fewer than two days in advance of proposed utility interruptions.
   b. Do not proceed with utility interruptions without the Owner‘s written permission.

1.2 PRODUCTS

A. Piping Materials
1. Refer to Part 1.3 "Piping Application" Article for applications of pipes, tubes, fittings, and joining methods.
2. Refer to Division 33 Section "Common Work Results For Utilities" for commonly used joining materials.

B. Steel Pipes And Fittings
1. Steel Pipe: ASTM A 53/A 53M, Type E, Grade B, Standard Weight; with plain ends.
2. Nipples: ASTM A 733, Standard Weight, seamless, carbon-steel pipe complying with ASTM A 53/A 53M.

3. Malleable-Iron, Threaded Fittings: ASME B16.3, Classes 150 **OR** 300, **as directed**, with threads according to ASME B1.20.1.
4. Cast-Iron, Threaded Fittings: ASME B16.4, Classes 125 **OR** 250, **as directed**, standard pattern, with threads according to ASME B1.20.1.
5. Steel Welding Fittings: ASME B16.9 **OR** ASTM A 234/A 234M, **as directed**, seamless or welded.
6. Ductile-Iron, Grooved-End Fittings: ASTM A 536, ductile-iron casting with dimensions matching piping.
7. Steel-Pipe, Keyed Couplings: AWWA C606 for steel-pipe dimensions. Include ferrous housing sections, gasket suitable for hot water, and bolts and nuts.

C. Conduit Piping
1. Description: Factory-fabricated and -assembled, airtight and watertight, drainable, pressure-tested piping with conduit, inner pipe supports, and insulated carrier piping. Fabricate so insulation can be dried in place by forcing dry air through conduit.
2. Carrier Pipe: Steel pipe complying with ASTM A 53/A 53M, Type E, Grade B with beveled **OR** socket, **as directed**, ends for welded joints.
3. Carrier Pipe Insulation:
   a. Mineral-Wool Pipe Insulation: ASTM C 547, Type I, molded.
      1) Apparent Thermal Conductivity (k-Value): 0.31 at 200 deg F (0.044 at 93 deg C) mean temperature.
      2) Density: Maximum 10 lb/cu. ft. (160 kg/cu. m) average.
      3) Compressive Strength: 10 psig (69 kPa) minimum at 5 percent deformation.
      4) Bands: ASTM A 666, Type 304, stainless steel, 3/4 inch (19 mm) wide, 0.020 inch (0.5 mm) thick.
   b. Calcium Silicate Pipe Insulation: ASTM C 533, Type I; preformed, incombustible, inorganic, with non-asbestos fibrous reinforcement.
      1) Thermal Conductivity (k-Value): 0.60 at 500 deg F (0.087 at 260 deg C).
      2) Dry Density: 15 lb/cu. ft. (240 kg/cu. m) maximum.
      3) Compressive Strength: 60 psig (414 kPa) minimum at 5 percent deformation.
      4) Bands: ASTM A 666, Type 304, stainless steel, 3/4 inch (19 mm) wide, 0.020 inch (0.5 mm) thick.
   c. Polyisocyanurate Foam Pipe Insulation: ASTM C 591, preformed, rigid, cellular.
      1) Thermal Conductivity (k-Value): 0.14 at 75 deg F (0.020 at 24 deg C).
      2) Service Temperature: Minus 250 to plus 400 deg F (Minus 156 to plus 204 deg C).
      3) Moisture Absorption: ASTM D 2842, maximum 0.054 percent by volume.
      4) Minimum 90 percent closed cell.
      5) Dry Density: 2 lb/cu. ft. (32 kg/cu. m) maximum.
      6) Compressive Strength: 35 psig (242 kPa) minimum at 5 percent deformation.
      7) Water-Vapor Transmission: 1.26 perm inches (1.83 ng/Pa x s x m) according to ASTM E 96.
   d. Polyurethane Foam Pipe Insulation: ASTM C 591, preformed, rigid, cellular.
      1) Thermal Conductivity (k-Value): 0.13 at 75 deg F (0.019 at 24 deg C).
      2) Service Temperature: Minus 250 to plus 200 deg F (Minus 156 to plus 93 deg C).
      3) Moisture Absorption: ASTM D 2842, maximum 0.054 percent by volume.
      4) Minimum 90 percent closed cell.
      5) Dry Density: 2 lb/cu. ft. (32 kg/cu. m) maximum.
      6) Compressive Strength: 35 psig (242 kPa) minimum at 5 percent deformation.
      7) Water-Vapor Transmission: 1.26 perm inches (1.83 ng/Pa x s x m) according to ASTM E 96.
4. Minimum Clearance:
   a. Between Carrier Pipe Insulation and Conduit: 1 inch (25 mm).
   b. Between Insulation of Multiple Carrier Pipes: 3/16 inch (4.75 mm).
   c. Between Bottom of Carrier Pipe Insulation and Conduit: 1 inch (25 mm).
   d. Between Bottom of Bare, Carrier Pipe and Casing: 1-3/8 inches (35 mm).

5. Conduit: Spiral wound, steel. Finish conduit with 2 coats of fusion-bonded epoxy, minimum 20 mils (0.50 mm) thick. Cover with polyurethane foam insulation with a high-density polyethylene jacket; thickness indicated in Part 1.3 “Piping Application" Article, **as directed**.
   OR
   Conduit: Spiral wound, bare steel. Cover with polyurethane foam insulation with a high-density polyethylene jacket; thickness indicated in Part 1.3 "Piping Application" Article.
6. Carrier Piping Supports within Conduit: Corrugated galvanized steel with a maximum spacing of 10 feet (3 m).
7. Fittings: Factory-fabricated and -insulated elbows and tees. Elbows may be bent pipe equal to carrier pipe. Tees shall be factory fabricated and insulated, and shall be compatible with the carrier pipe.
8. Expansion Offsets and Loops: Size casing to contain piping expansion.
9. Conduit accessories include the following:
   a. Water Shed: Terminal end protector for carrier pipes entering building through floor, 3 inches (75 mm) deep and 2 inches (50 mm) larger than casing; terminate casing 20 inches (500 mm) above the floor level.
   b. Guides and Anchors: Steel plate welded to carrier pipes and to casing, complete with vent and drainage openings inside casing.
   c. End Seals: Steel plate welded to carrier pipes and to casing, complete with drain and vent openings on vertical centerline.
   d. Gland Seals: Packed stuffing box and gland follower mounted on steel plate, welded to end of casing, permitting axial movement of carrier piping, with drain and vent connections on vertical centerline.
   e. Joint Kit: Half-shell, pourable or split insulation and shrink-wrap sleeve.
10. Source Quality Control: Factory test the conduit to 15 psig (105 kPa) for a minimum of 2 minutes with no change in pressure. Factory test the carrier pipe to 150 percent of the operating pressure of system. Furnish test certificates.

D. Cased Piping
1. Description: Factory-fabricated piping with carrier pipe, insulation, and casing.
2. Carrier Pipe: Steel pipe complying with ASTM A 53/A 53M, Type E, Grade B with beveled **OR** socket, **as directed**, ends for welded joints.
3. Carrier Pipe Insulation:
   a. Polyurethane Foam Pipe Insulation: ASTM C 591, preformed, rigid, cellular.
      1) Thermal Conductivity (k-Value): 0.13 at 75 deg F (0.019 at 24 deg C).
      2) Service Temperature: Minus 250 to plus 200 deg F (Minus 156 to plus 93 deg C).
      3) Moisture Absorption: ASTM D 2842, maximum 0.054 percent by volume.
      4) Minimum 90 percent closed cell.
      5) Dry Density: 2 lb/cu. ft. (32 kg/cu. m) maximum.
      6) Compressive Strength: 35 psig (242 kPa) minimum at 5 percent deformation.
      7) Water-Vapor Transmission: 1.26 perm inches (1.83 ng/Pa x s x m) according to ASTM E 96.
4. Casing: High-density polyethylene **OR** Filament-wound, fiberglass-reinforced polyester resin **OR** PVC, **as directed**.
5. Casing accessories include the following:
   a. Joint Kit: Half-shell, pourable or split insulation, casing sleeve, and shrink-wrap sleeve.
   b. Expansion Blanket: Elastomeric foam, formed to fit over piping.
   c. End Seals: Shrink wrap the casing material to seal watertight around casing and carrier pipe.
6. Source Quality Control: Factory test the carrier pipe to 150 percent of the operating pressure of system. Furnish test certificates.

E. Loose-Fill Insulation
1. Granular, Loose-Fill Insulation: Inorganic, nontoxic, nonflammable, sodium potassium aluminum silicate with calcium carbonate filler. Include chemical treatment that renders insulation hydrophobic.

a. Thermal Conductivity (k-Value): 0.60 at 175 deg F (0.087 at 79 deg C) and 0.65 at 300 deg F (0.094 at 149 deg C).
b. Application Temperature Range: 35 to 800 deg F (2 to 426 deg C).
c. Dry Density: 40 to 42 lb/cu. ft. (640 to 672 kg/cu. m).
d. Strength: 12,000 lb/sq. ft. (58 600 kg/sq. m).

2. Powder, Loose-Fill Insulation: Inert, nontoxic, nonflammable, calcium carbonate particles. Include chemical treatment that renders insulation hydrophobic.
a. Thermal Conductivity (k-Value): ASTM C 177, 0.58 at 100 deg F (0.084 at 37 deg C) and 0.68 at 300 deg F (0.098 at 149 deg C).
b. Application Temperature Range: Minus 273 to plus 480 deg F (Minus 169 to plus 250 deg C).
c. Dry Density: Approximately 60 lb/cu. ft. (960 kg/cu. m).
d. Strength: 12,000 lb/sq. ft. (58 600 kg/sq. m).

1.3 EXECUTION

A. Earthwork: Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

B. Piping Application
1. Hot-Water Piping: Schedule 40 **OR** Schedule 80, **as directed**, steel pipe with cast-iron, threaded fittings and threaded **OR** steel fittings and welded **OR** ductile-iron, grooved-end fittings and mechanical, **as directed**, joints; granular **OR** powder, loose-fill insulation.
OR
Hot-Water Piping: Conduit piping with mineral-wool **OR** calcium silicate **OR** polyisocyanurate **OR** polyurethane, **as directed**, carrier-pipe insulation and with coated **OR** coated and insulated, **as directed**, conduit.
a. Insulation Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
OR
Hot-Water Piping: Cased piping with polyurethane carrier-pipe insulation.
2. Chilled-Water Piping: Schedule 40 **OR** Schedule 80, **as directed**, steel pipe with cast-iron, threaded fittings and threaded **OR** steel welding fittings and welded **OR** ductile-iron, grooved-end fittings and mechanical, **as directed**, joints; granular **OR** powder, **as directed**, loose-fill insulation.
OR
Chilled-Water Piping: Conduit piping with mineral-wool **OR** calcium silicate **OR** polyisocyanurate **OR** polyurethane, **as directed**, carrier-pipe insulation and with coated **OR** coated and insulated, **as directed**, conduit.
a. Insulation Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
OR
Chilled-Water Piping: Cased piping with polyurethane carrier-pipe insulation.
3. Condenser-Water Piping: Schedule 40 **OR** Schedule 80, **as directed**, steel pipe with cast-iron, threaded fittings and threaded **OR** steel welding fittings and welded **OR** ductile-iron, grooved-end fittings and mechanical, **as directed**, joints; granular **OR** powder, **as directed**, loose-fill insulation.
OR
Condenser-Water Piping: Conduit piping with mineral-wool **OR** calcium silicate **OR** polyisocyanurate **OR** polyurethane, **as directed**, carrier-pipe insulation and with coated **OR** coated and insulated, **as directed**, conduit.
a. Insulation Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
OR
Condenser-Water Piping: Cased piping with polyurethane carrier-pipe insulation.

C. Piping Installation

1. General Locations and Arrangements: Drawings indicate general location and arrangement of piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated, unless deviations to layout are approved.
2. Remove any standing water in the bottom of trench.
3. Bed the pipe on a minimum 6-inch (150-mm) layer of granular fill material with a minimum 6-inch (150-mm) clearance between the pipes.
4. Do not insulate piping or backfill piping trench until field quality-control testing has been completed and results approved.
5. Install piping at uniform grade of 0.2 percent upward in direction of flow or as indicated.
6. Install components with pressure rating equal to or greater than system operating pressure.
7. Install piping free of sags and bends.
8. Install fittings for changes in direction and branch connections.
9. Refer to Division 23 Section "Common Work Results For Hvac" for sleeves and mechanical sleeve seals through exterior building walls.
10. Secure anchors with concrete thrust blocks. Concrete is specified in Division 03 Section "Cast-in-place Concrete".
11. Connect to hydronic piping where it passes through the building wall. Hydronic piping inside the building is specified in Division 23 Section "Hydronic Piping".

D. Loose-Fill Insulation Installation
1. Do not disturb the bottom of trench, or compact and stabilize it to ensure proper support.
2. Remove any standing water in the bottom of trench.
3. Form insulation trench by excavation or by installing drywall side forms to establish required height and width of the insulation.
4. Support piping with proper pitch, separation, and clearance to backfill or side forms using temporary supporting devices that can be removed after back filling with insulation.
5. Place insulation and backfill after field quality-control testing has been completed and results approved.
6. Apply bitumastic coating to carbon-steel anchors and guides. Pour concrete thrust blocks and anchors. Refer to Division 03 Section "Cast-in-place Concrete" for concrete and reinforcement.
7. Wrap piping at expansion loops and offsets with mineral-wool insulation of thickness appropriate for calculated expansion amount.
8. Pour loose-fill insulation to required dimension agitating insulation to eliminate voids around piping.
9. Remove temporary hangers and supports.
10. Cover loose-fill insulation with polyethylene sheet a minimum of 4 mils (0.10 mm) thick, and empty loose-fill insulation bags on top.
11. Manually backfill 6 inches (150 mm) of clean backfill. If mechanical compaction is required, manually backfill to 12 inches (300 mm) before using mechanical-compaction equipment.

E. Joint Construction
1. Refer to Division 33 Section "Common Work Results For Utilities" for basic piping joint construction.
2. Keyed-Coupling Joints: Cut- or roll-groove pipes. Assemble joints with keyed couplings, gaskets, lubricant, and bolts.
3. Conduit and Cased Piping Joints: Assemble sections and finish joints with pourable or split insulation, exterior jacket sleeve, and apply shrink-wrap seals as required by manufacturer's written installation instructions.

F. Identification: Install continuous plastic underground warning tapes during back filling of trenches for underground hydronic distribution piping. Locate 6 to 8 inches (150 to 200 mm) below finished grade, directly over piping. Refer to Division 31 Section "Earth Moving" for warning-tape materials and devices and their installation.

G. Field Quality Control

1. Prepare hydronic piping for testing according to ASME B31.9 and as follows:
   a. Leave joints, including welds, uninsulated and exposed for examination during test.
   b. Isolate equipment. Do not subject equipment to test pressure.
   c. Install relief valve set at pressure no more than one-third higher than test pressure.
   d. Fill system with water. Where there is risk of freezing, air or a safe, compatible liquid may be used.
   e. Use vents installed at high points to release trapped air while filling system.
2. Test hydronic piping as follows:
   a. Subject hydronic piping to hydrostatic test pressure that is not less than 1.5 times the design pressure.
   b. After hydrostatic test pressure has been applied for 10 minutes, examine joints for leakage. Remake leaking joints using new materials and repeat hydrostatic test until no leaks exist.
3. Test conduit as follows:
   a. Seal vents and drains and subject conduit to 15 psig (105 kPa) for 4 hours with no loss of pressure. Repair leaks and retest as required.
4. Prepare a written report of testing.

END OF SECTION 33 14 13 23a

SECTION 33 14 13 23b - GROUND-LOOP HEAT-PUMP PIPING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for ground-loop, heat-pump piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes piping for horizontal or vertical, direct-buried, ground-loop, heat-pump systems that operate between 23 and 104 deg F (minus 5 and plus 40 deg C).

C. Performance Requirements
1. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
   a. Ground-Loop, Heat-Pump Piping: 160 psig (1100 kPa) **OR** 200 psig (1380 kPa), **as directed**

D. Submittals
1. Product Data: For the following:
   a. Pipe and fittings.
   b. Joining method and equipment.
   c. Propylene glycol solution.
2. Field quality-control test reports.

1.2 PRODUCTS

A. Pipes And Fittings
1. PE Pipe: ASTM D 2239, SIDR Numbers 5.3, 7, 9, or 11.5; with PE compound number required to achieve required system working pressure.
   a. Molded PE Fittings: ASTM D 2683 or ASTM D 3261, PE resin, socket- or butt-fusion type, made to match PE pipe dimensions and class.
2. U-Bend Assembly: Factory fabricated with embossed depth stamp every 24 inches (600 mm) **OR** 36 inches (900 mm), **as directed** from U-bend.

B. Borehole Backfill
1. Surface Seal: Bentonite **OR** Cement, **as directed,** with thermal conductivity greater than 1.2 Btu/h x sq. ft. x deg F (0.7 W/sq. m x K).
2. Backfill below Surface Seal: Natural or manufactured sand specified in Division 31 Section "Earth Moving".

C. Antifreeze Solution
1. Propylene Glycol: Minimum 99 percent propylene glycol with corrosion inhibitors and environmental stabilizer additives to be mixed with water to protect the piping circuit and connected equipment from physical damage from freezing or corrosion.
2. Quantity: Sufficient solution for initial system startup and for preventive maintenance for one year from date of Final Completion.
3. Dilution Water: Chloride content shall be less than 25 ppm, sulfate less than 25 ppm, and hardness less than 100 ppm.

1.3 EXECUTION

A. Earthwork
1. Excavating, trenching, warning tape, and backfilling are specified in Division 31 Section "Earth Moving".

B. Horizontal Piping Installation
1. Separate trenches by 10 feet (3 m) minimum, unless otherwise indicated. Remove rocks in trenches that could contact pipe.
2. Backfill to 24 inches (600 mm) above pipe with mud developed from excavated rock-free soil or with sand, pea gravel, or fly ash. Backfill from slurry level to grade with excavated soil, compacting as specified for pipe burial in Division 31 Section "Earth Moving".
3. Extend pipe from trench onto the bottom of the body of water at an elevation that is at least 12 inches (300 mm) below frost line. Seal membrane or impervious liner under the body of water after installing piping.
4. Install PE piping in trenches according to ASTM D 2774 or ASTM F 645.
   a. Clean PE pipe and fittings and make heat-fusion joints according to ASTM D 2657. Minimize number of joints.
5. Purge, flush, and pressure test piping before backfilling trenches.
6. Install continuous detectable warning tape for underground piping. Locate tape a minimum of 24 inches (600 mm) below finished grade, directly over piping. Underground warning tapes are specified in Division 31 Section "Earth Moving".
7. Common piping installation requirements are specified in Division 23 Section "Common Work Results For Hvac".

C. Vertical Piping Installation
1. Install PE piping in boreholes according to ASTM D 2774 or ASTM F 645.
   a. Clean PE pipe and fittings and make heat-fusion joints according to ASTM D 2657. Minimize number of joints.
2. Purge, flush, and pressure test piping before backfilling boreholes.
3. After installation of loop pipe in borehole, fill piping loop with water or antifreeze solution, and pump backfill into borehole to discharge at base of borehole.
4. Fill borehole with backfill to a point at least 60 inches (1524 mm) below grade and backfill remainder with surface seal material.
5. Extend piping and connect to water-source, ground-loop, heat-pump piping systems at outside face of building wall in locations and pipe sizes indicated.
   a. Terminate water-service piping at building wall until building water-source, ground-loop, heat-pump piping systems are installed. Terminate piping with caps. Make connections to building water-source, ground-loop, heat-pump piping systems when those systems are installed.
6. Wall sleeves are specified in Division 23 Section "Common Work Results For Hvac".
7. Mechanical sleeve seals are specified in Division 22 Section "Common Work Results For Plumbing".

D. Antifreeze Solution Fill
1. Fill system with required quantity of propylene glycol and water to provide minus 10 deg F (minus 23 deg C) freezing temperature.
2. Test the dilute solution using gas chromatography to verity concentration of propylene glycol, and forward report to the Owner.

E. Connections
1. Drawings indicate general arrangement of piping, fittings, and specialties.

F. Field Quality Control

1. Piping Tests: Fill piping 24 hours before testing and apply test pressure to stabilize piping. Use potable water only.
2. Hydrostatic Tests: Test at not less than 1-1/2 times the pipe working-pressure rating allowing for static pressure of borehole depth.
   a. Increase pressure in 50-psig (345-kPa) increments and inspect each joint between increments. Hold at test pressure for 30 minutes. Slowly increase to next test pressure increment and hold for 30 minutes. After testing at maximum test pressure, reduce pressure to 30 psig (207 kPa). Hold for 90 minutes, and measure pressure at 30-minute intervals. Repair leaks and retest until no leaks exist.
3. Prepare reports of testing activity.

END OF SECTION 33 14 13 23b

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Task	Specification	Specification Description
33 14 13 23	01 22 16 00	No Specification Required
33 14 13 23	21 05 23 00	Piped Utilities Basic Materials And Methods
33 14 13 23	13 12 13 00	Water Distribution
33 14 13 23	23 11 23 00a	Monitoring Wells
33 14 13 23	22 11 23 23	Water Supply Wells
33 14 13 23	22 05 76 00	Sanitary Sewerage
33 14 13 23	32 91 19 13a	Septic Tank Systems
33 14 13 23	31 05 13 00	Subdrainage
33 14 13 23	33 42 11 00	Storm Drainage
33 14 13 36	21 05 23 00	Piped Utilities Basic Materials And Methods
33 14 13 36	22 11 23 23	Water Supply Wells
33 14 13 36	33 14 13 23a	Hydronic Distribution
33 14 13 36	23 05 29 00	Steam Distribution
33 14 13 39	21 05 23 00	Piped Utilities Basic Materials And Methods
33 14 13 39	13 12 13 00	Water Distribution
33 14 13 43	21 05 23 00	Piped Utilities Basic Materials And Methods
33 14 13 43	13 12 13 00	Water Distribution
33 14 13 43	22 11 23 23	Water Supply Wells
33 14 13 43	22 05 76 00	Sanitary Sewerage
33 14 13 43	33 14 13 23a	Hydronic Distribution
33 14 13 43	23 05 29 00	Steam Distribution
33 14 13 53	01 22 16 00	No Specification Required
33 14 13 53	07 63 00 00	Common Work Results for Fire Suppression
33 14 13 53	07 63 00 00a	Common Work Results for Plumbing
33 14 13 53	07 63 00 00b	Common Work Results for HVAC
33 14 13 53	22 11 16 00	Domestic Water Piping
33 14 13 53	22 11 16 00a	Sanitary Waste And Vent Piping
33 14 13 53	22 11 16 00b	Storm Drainage Piping
33 14 13 53	22 11 16 00c	Hydronic Piping
33 14 13 53	22 11 16 00d	Steam And Condensate Piping
33 14 13 53	22 11 16 00e	Refrigerant Piping
33 14 13 53	22 11 16 00f	General-Service Compressed-Air Piping
33 14 19 00	01 22 16 00	No Specification Required
33 14 19 00	21 05 23 00	Piped Utilities Basic Materials And Methods
33 14 19 00	13 12 13 00	Water Distribution
33 19 13 23	13 12 13 00	Water Distribution
33 19 13 23	21 05 19 00	Meters and Gages for Plumbing Piping
33 19 13 23	21 05 19 00a	Meters and Gages for HVAC Piping
33 19 16 23	01 22 16 00	No Specification Required
33 19 16 23	13 12 13 00	Water Distribution
33 19 16 23	21 05 19 00	Meters and Gages for Plumbing Piping
33 19 16 23	21 05 19 00a	Meters and Gages for HVAC Piping
33 19 19 00	01 22 16 00	No Specification Required
33 19 19 00	13 12 13 00	Water Distribution
33 19 19 00	21 05 19 00	Meters and Gages for Plumbing Piping
33 19 19 00	21 05 19 00a	Meters and Gages for HVAC Piping
33 31 11 00	21 05 23 00	Piped Utilities Basic Materials And Methods
33 31 11 00	33 14 13 23	Sand Drains
33 31 11 00	13 12 13 00	Water Distribution
33 31 11 00	23 11 23 00a	Monitoring Wells
33 31 11 00	22 11 23 23	Water Supply Wells
33 31 11 00	22 05 76 00	Sanitary Sewerage
33 31 11 00	32 91 19 13a	Septic Tank Systems
33 31 11 00	33 14 13 23a	Hydronic Distribution
33 31 11 00	31 05 13 00	Subdrainage

33 31 11 00	33 42 11 00	Storm Drainage
33 32 16 00	01 22 16 00	No Specification Required
33 32 16 00	22 13 29 13b	Sewage Pumps
33 34 13 13	32 91 19 13a	Septic Tank Systems
33 34 13 23	32 91 19 13a	Septic Tank Systems
33 34 13 33	32 91 19 13a	Septic Tank Systems
33 34 51 00	32 91 19 13a	Septic Tank Systems
33 34 53 13	32 91 19 13a	Septic Tank Systems
33 34 56 00	32 91 19 13a	Septic Tank Systems
33 41 16 13	01 22 16 00	No Specification Required
33 41 16 13	21 05 23 00	Piped Utilities Basic Materials And Methods
33 41 16 13	22 05 76 00	Sanitary Sewerage
33 41 16 13	32 91 19 13a	Septic Tank Systems
33 41 16 13	31 05 13 00	Subdrainage
33 41 16 13	33 42 11 00	Storm Drainage
33 41 16 13	22 11 16 00b	Storm Drainage Piping
33 41 16 13	22 05 76 00a	Storm Drainage Piping Specialties
33 41 19 13	21 05 23 00	Piped Utilities Basic Materials And Methods
33 41 19 13	31 05 13 00	Subdrainage

SECTION 33 42 11 00 - STORM DRAINAGE

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for storm drainage. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Pipe and fittings.
b. Nonpressure transition couplings.
c. Pressure pipe couplings.
d. Expansion joints and deflection fittings.
e. Backwater valves.
f. Cleanouts.
g. Drains.
h. Encasement for piping.
i. Manholes.
j. Channel drainage systems.
k. Catch basins.
l. Stormwater inlets.
m. Stormwater detention structures.
n. Pipe outlets.
o. Dry wells.
p. Stormwater disposal systems.

C. Definitions
1. FRP: Fiberglass-reinforced plastic.

D. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings:
a. Manholes: Include plans, elevations, sections, details, frames, and covers.
b. Catch basins, stormwater inlets, and dry wells. Include plans, elevations, sections, details, frames, covers, and grates.
c. Stormwater Detention Structures: Include plans, elevations, sections, details, frames, covers, design calculations, and concrete design-mix reports.
3. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from storm drainage system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.
4. Profile Drawings: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet (1:500) and vertical scale of not less than 1 inch equals 5 feet (1:50). Indicate manholes and piping. Show types, sizes, materials, and elevations of other utilities crossing system piping.
5. Product Certificates: For each type of cast-iron soil pipe and fitting, from manufacturer.
6. Field quality-control reports.

E. Delivery, Storage, And Handling
1. Do not store plastic manholes, pipe, and fittings in direct sunlight.
2. Protect pipe, pipe fittings, and seals from dirt and damage.
3. Handle manholes according to manufacturer's written rigging instructions.

4. Handle catch basins and stormwater inlets according to manufacturer's written rigging instructions.

F. Project Conditions
1. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
a. Notify the Owner no fewer than two days in advance of proposed interruption of service.
b. Do not proceed with interruption of service without the Owner written permission.

1.2 PRODUCTS

A. Hub-And-Spigot, Cast-Iron Soil Pipe And Fittings
1. Pipe and Fittings: ASTM A 74, Service class **OR** Extra-Heavy class, **as directed.**
2. Gaskets: ASTM C 564, rubber.
3. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

B. Hubless Cast-Iron Soil Pipe And Fittings
1. Pipe and Fittings: ASTM A 888 or CISPI 301.
2. CISPI-Trademarked, Shielded Couplings:
a. Description: ASTM C 1277 and CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
3. Heavy-Duty, Shielded Couplings:
a. Description: ASTM C 1277 and ASTM C 1540, with stainless-steel shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
4. Cast-Iron, Shielded Couplings:
a. Description: ASTM C 1277 and ASTM A 48/A 48M, two-piece, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.

C. Ductile-Iron, Culvert Pipe And Fittings
1. Pipe: ASTM A 716, for push-on joints.
2. Standard Fittings: AWWA C110, ductile or gray iron, for push-on joints.
3. Compact Fittings: AWWA C153, for push-on joints.
4. Gaskets: AWWA C111, rubber.

D. Ductile-Iron, Pressure Pipe And Fittings
1. Push-on-Joint Piping:
a. Pipe: AWWA C151, for push-on joints.
b. Standard Fittings: AWWA C110, ductile or gray iron, for push-on joints.
c. Compact Fittings: AWWA C153, for push-on joints.
d. Gaskets: AWWA C111, rubber, of shape matching pipe and fittings.
2. Mechanical-Joint Piping:
a. Pipe: AWWA C151, with bolt holes in bell.
b. Standard Fittings: AWWA C110, ductile or gray iron, with bolt holes in bell.
c. Compact Fittings: AWWA C153, with bolt holes in bells.
d. Glands: Cast or ductile iron, with bolt holes and high-strength, cast-iron or high-strength, low-alloy steel bolts and nuts.
e. Gaskets: AWWA C111, rubber, of shape matching pipe, fittings, and glands.

E. Steel Pipe And Fittings

1. Corrugated-Steel Pipe and Fittings: ASTM A 760/A 760M, Type I with fittings of similar form and construction as pipe.
   a. Special-Joint Bands: Corrugated steel with O-ring seals.
   b. Standard-Joint Bands: Corrugated steel.
   c. Coating: Aluminum **OR** Zinc, **as directed**.

F. Aluminum Pipe And Fittings
1. Corrugated Aluminum Pipe and Fittings: ASTM B 745/B 745M, Type I with fittings of similar form and construction as pipe.
   a. Special-Joint Bands: Corrugated steel with O-ring seals.
   b. Standard-Joint Bands: Corrugated steel.

G. ABS Pipe And Fittings
1. ABS Sewer Pipe and Fittings: ASTM D 2751, with bell-and-spigot ends for gasketed joints.
   a. NPS 3 to NPS 6 (DN 80 to DN 150): SDR 35.
   b. NPS 8 to NPS 12 (DN 200 to DN 300): SDR 42.
2. Gaskets: ASTM F 477, elastomeric seals.

H. PE Pipe And Fittings
1. Corrugated PE Drainage Pipe and Fittings NPS 3 to NPS 10 (DN 80 to DN 250): AASHTO M 252M, Type S, with smooth waterway for coupling joints.
   a. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with tube and fittings.
   b. Soiltight Couplings: AASHTO M 252M, corrugated, matching tube and fittings.
2. Corrugated PE Pipe and Fittings NPS 12 to NPS 60 (DN 300 to DN 1500): AASHTO M 294M, Type S, with smooth waterway for coupling joints.
   a. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with pipe and fittings.
   b. Soiltight Couplings: AASHTO M 294M, corrugated, matching pipe and fittings.

I. PVC Pipe And Fittings
1. PVC Cellular-Core Piping:
   a. PVC Cellular-Core Pipe and Fittings: ASTM F 891, Sewer and Drain Series, PS 50 minimum stiffness, PVC cellular-core pipe with plain ends for solvent-cemented joints.
   b. Fittings: ASTM D 3034, SDR 35, PVC socket-type fittings.
2. PVC Corrugated Sewer Piping:
   a. Pipe: ASTM F 949, PVC, corrugated pipe with bell-and-spigot ends for gasketed joints.
   b. Fittings: ASTM F 949, PVC molded or fabricated, socket type.
   c. Gaskets: ASTM F 477, elastomeric seals.
3. PVC Profile Sewer Piping:
   a. Pipe: ASTM F 794, PVC profile, gravity sewer pipe with bell-and-spigot ends for gasketed joints.
   b. Fittings: ASTM D 3034, PVC with bell ends.
   c. Gaskets: ASTM F 477, elastomeric seals.
4. PVC Type PSM Sewer Piping:
   a. Pipe: ASTM D 3034, SDR 35, PVC Type PSM sewer pipe with bell-and-spigot ends for gasketed joints.
   b. Fittings: ASTM D 3034, PVC with bell ends.
   c. Gaskets: ASTM F 477, elastomeric seals.
5. PVC Gravity Sewer Piping:
   a. Pipe and Fittings: ASTM F 679, T-1 **OR** T-2, **as directed**, wall thickness, PVC gravity sewer pipe with bell-and-spigot ends and with integral ASTM F 477, elastomeric seals for gasketed joints.
6. PVC Pressure Piping:
   a. Pipe: AWWA C900, Class 100 **OR** Class 150 **OR** Class 200, **as directed**, PVC pipe with bell-and-spigot ends for gasketed joints.

b. Fittings: AWWA C900, Class 100 **OR** Class 150 **OR** Class 200, **as directed**, PVC pipe with bell ends
c. Gaskets: ASTM F 477, elastomeric seals.

7. PVC Water-Service Piping:
a. Pipe: ASTM D 1785, Schedule 40 **OR** Schedule 80, **as directed**, PVC, with plain ends for solvent-cemented joints.
b. Fittings: ASTM D 2466, Schedule 40 **OR** ASTM D 2467, Schedule 80, **as directed**, PVC, socket type.

J. Fiberglass Pipe And Fittings
1. Fiberglass Sewer Pipe: ASTM D 3262, RTRP for gasketed joints fabricated with Type 2, polyester **OR** Type 4, epoxy, **as directed**, resin.
a. Liner: Reinforced thermoset **OR** Nonreinforced thermoset **OR** Thermoplastic **OR** No liner, **as directed**.
b. Grade: Reinforced, surface layer matching pipe resin **OR** Nonreinforced, surface layer matching pipe resin **OR** No surface layer, **as directed**.
c. Stiffness: 9 psig (62 kPa) **OR** 18 psig (124 kPa) **OR** 36 psig (248 kPa) **OR** 72 psig (496 kPa), **as directed**.
2. Fiberglass Nonpressure Fittings: ASTM D 3840, RTRF for gasketed joints.
a. Laminating Resin: Type 1, polyester **OR** Type 2, epoxy, **as directed**, resin.
b. Reinforcement: Grade with finish compatible with resin.
3. Gaskets: ASTM F 477, elastomeric seals.

K. Concrete Pipe And Fittings
1. Nonreinforced-Concrete Sewer Pipe and Fittings: ASTM C 14 (ASTM C 14M), Class 1 **OR** Class 2 **OR** Class 3, **as directed**, with bell-and-spigot **OR** tongue-and-groove, **as directed** ends and gasketed joints with ASTM C 443 (ASTM C 443M), rubber gaskets **OR** sealant joints with ASTM C 990 (ASTM C 990M), bitumen or butyl-rubber sealant, **as directed**.
2. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76 (ASTM C 76M).
a. Bell-and-spigot **OR** Tongue-and-groove, **as directed**, ends and gasketed joints with ASTM C 443 (ASTM C 443M), rubber gaskets **OR** sealant joints with ASTM C 990 (ASTM C 990M), bitumen or butyl-rubber sealant, **as directed**.
b. Class I, Wall A **OR** Wall B, **as directed**.
c. Class II, Wall A **OR** Wall B **OR** Wall C, **as directed**.
d. Class III, Wall A **OR** Wall B **OR** Wall C, **as directed**.
e. Class IV, Wall A **OR** Wall B **OR** Wall C, **as directed**.
f. Class V, Wall B **OR** Wall C, **as directed**.

L. Nonpressure Transition Couplings
1. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.
2. Sleeve Materials:
a. For Concrete Pipes: ASTM C 443 (ASTM C 443M), rubber.
b. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
c. For Fiberglass Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
d. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
e. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
3. Unshielded, Flexible Couplings:
a. Description: Elastomeric sleeve, with stainless-steel shear ring, **as directed**, and corrosion-resistant-metal tension band and tightening mechanism on each end.
4. Shielded, Flexible Couplings:

a. Description: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

5. Ring-Type, Flexible Couplings:
   a. Description: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.

M. Pressure Pipe Couplings
1. Description: AWWA C219, tubular-sleeve coupling, with center sleeve, gaskets, end rings, and bolt fasteners.
2. Metal, bolted, sleeve-type, reducing or transition coupling, for joining underground pressure piping. Include 150-psig (1035-kPa) **OR** 200-psig (1380-kPa), **as directed**, minimum pressure rating and ends sized to fit adjoining pipes.
3. Center-Sleeve Material: Manufacturer's standard **OR** Carbon steel **OR** Stainless steel **OR** Ductile iron **OR** Malleable iron, **as directed**.
4. Gasket Material: Natural or synthetic rubber.
5. Metal Component Finish: Corrosion-resistant coating or material.

N. Expansion Joints And Deflection Fittings
1. Ductile-Iron Flexible Expansion Joints:
   a. Description: Compound fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include two gasketed ball-joint sections and one or more gasketed sleeve sections, rated for 250-psig (1725-kPa) minimum working pressure and for offset and expansion indicated.
2. Ductile-Iron Expansion Joints:
   a. Description: Three-piece assembly of telescoping sleeve with gaskets and restrained-type, ductile-iron or steel with protective coating, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Include rating for 250-psig (1725-kPa) minimum working pressure and for expansion indicated.
3. Ductile-Iron Deflection Fittings:
   a. Description: Compound-coupling fitting, with ball joint, flexing section, gaskets, and restrained-joint ends, complying with AWWA C110 or AWWA C153. Include rating for 250-psig (1725-kPa) minimum working pressure and for up to 15 degrees of deflection.

O. Backwater Valves
1. Cast-Iron Backwater Valves:
   a. Description: ASME A112.14.1, gray-iron body and bolted cover, with bronze seat.
   b. Horizontal type; with swing check valve and hub-and-spigot ends.
   c. Combination horizontal and manual gate-valve type; with swing check valve, integral gate valve, and hub-and-spigot ends.
   d. Terminal type; with bronze seat, swing check valve, and hub inlet.
2. Plastic Backwater Valves:
   a. Description: Horizontal type; with PVC body, PVC removable cover, and PVC swing check valve.

P. Cleanouts
1. Cast-Iron Cleanouts:
   a. Description: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.
   b. Top-Loading Classification(s): Light Duty **OR** Medium Duty **OR** Heavy Duty **OR** Extra-Heavy Duty, **as directed**.
   c. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.
2. Plastic Cleanouts:

a. Description: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

Q. Drains
1. Cast-Iron Area Drains:
a. Description: ASME A112.6.3 gray-iron round body with anchor flange and round secured **OR** non-secured, **as directed**, grate. Include bottom outlet with inside calk or spigot connection, of sizes indicated.
b. Top-Loading Classification(s): Medium Duty **OR** Heavy Duty, **as directed**.
2. Cast-Iron Trench Drains:
a. Description: ASME A112.6.3, 6-inch- (150-mm-) wide top surface, rectangular body with anchor flange or other anchoring device, and rectangular secured **OR** non-secured, **as directed**, grate. Include units of total length indicated and quantity of bottom outlets with inside calk or spigot connections, of sizes indicated.
b. Top-Loading Classification(s): Medium Duty **OR** Heavy Duty **OR** Extra-Heavy Duty **OR** Medium and Heavy Duty **OR** Medium and Extra-Heavy Duty **OR** Heavy and Extra-Heavy Duty **OR** Medium, Heavy, and Extra-Heavy Duty, **as directed**.
3. Steel Trench Drains:
a. Description: Factory fabricated from ASTM A 242/A 242M, welded steel plate, to form rectangular body with uniform bottom downward slope of 2 percent toward outlet, anchor flange, and grate. Include units of total length indicated, bottom outlet of size indicated, outlet strainer, acid-resistant enamel coating on inside and outside surfaces, and grate with openings of total free area at least two times cross-sectional area of outlet.
b. Plate Thicknesses: 1/8 inch (3.2 mm) **OR** 1/4 inch (6.4 mm), **as directed**.
c. Overall Widths: 7-1/2 inches (190 mm) **OR** 12-1/3 inches (313 mm), **as directed**.
1) Grate Openings: 1/4 inch (6.4 mm) circular **OR** 3/8 inch (9.5 mm) circular **OR** 3/8-by-3-inch (9.5-by-76-mm) slots, **as directed**.

R. Encasement For Piping
1. Standard: ASTM A 674 or AWWA C105.
2. Material: Linear low-density polyethylene film of 0.008-inch (0.20-mm) **OR** high-density, cross-laminated polyethylene film of 0.004-inch (0.10-mm), **as directed**, minimum thickness.
3. Form: Sheet **OR** Tube, **as directed**.
4. Color: Black **OR** Natural, **as directed**.

S. Manholes
1. Standard Precast Concrete Manholes:
a. Description: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.
b. Diameter: 48 inches (1200 mm) minimum unless otherwise indicated.
c. Ballast: Increase thickness of precast concrete sections or add concrete to base section as required to prevent flotation.
d. Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (102-mm) minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
e. Riser Sections: 4-inch (102-mm) minimum thickness, and lengths to provide depth indicated.
f. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated, and top of cone of size that matches grade rings.
g. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
h. Resilient Pipe Connectors: ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection.
i. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps; FRP ladder; or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing

rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches (1500 mm).

j. Adjusting Rings: Interlocking HDPE rings with level or sloped edge in thickness and diameter matching manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.

OR

Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover, and height as required to adjust manhole frame and cover to indicated elevation and slope.

2. Designed Precast Concrete Manholes:
   a. Description: ASTM C 913; designed according to ASTM C 890 for A-16 (AASHTO HS20-44), heavy-traffic, structural loading; of depth, shape, and dimensions indicated, with provision for sealant joints.
   b. Ballast: Increase thickness of one or more precast concrete sections or add concrete to manhole as required to prevent flotation.
   c. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
   d. Resilient Pipe Connectors: ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection.
   e. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps; FRP ladder; or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches (1500 mm).
   f. Adjusting Rings: Interlocking HDPE rings with level or sloped edge in thickness and diameter matching manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.

   OR

   Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope.
3. Fiberglass Manholes:
   a. Description: ASTM D 3753.
   b. Diameter: 48 inches (1200 mm) minimum unless otherwise indicated.
   c. Ballast: Increase thickness of concrete base as required to prevent flotation.
   d. Base Section: Concrete, 6-inch (150-mm) minimum thickness.
   e. Resilient Pipe Connectors (if required): ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection.
   f. Steps: Individual FRP steps or FRP ladder, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches (1500 mm).
   g. Adjusting Rings: Interlocking HDPE rings with level or sloped edge in thickness and diameter matching manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.

   OR

   Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover, and height as required to adjust manhole frame and cover to indicated elevation and slope.
4. Manhole Frames and Covers:

a. Description: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch- (102-mm-) minimum width flange and 26-inch- (660-mm-) diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."
b. Material: ASTM A 536, Grade 60-40-18 ductile **OR** ASTM A 48/A 48M, Class 35 gray, **as directed**, iron unless otherwise indicated.

T. Concrete
1. General: Cast-in-place concrete according to ACI 318, ACI 350/350R (ACI 350M/350RM), and the following:
a. Cement: ASTM C 150, Type II.
b. Fine Aggregate: ASTM C 33, sand.
c. Coarse Aggregate: ASTM C 33, crushed gravel.
d. Water: Potable.
2. Portland Cement Design Mix: 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio.
a. Reinforcing Fabric: ASTM A 1064/A 1064M, steel, welded wire fabric, plain.
b. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.
3. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.
a. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.
1) Invert Slope: 1 **OR** 2, **as directed**, percent through manhole.
b. Benches: Concrete, sloped to drain into channel.
1) Slope: 4 **OR** 8, **as directed**, percent.
4. Ballast and Pipe Supports: Portland cement design mix, 3000 psi (20.7 MPa) minimum, with 0.58 maximum water/cementitious materials ratio.
a. Reinforcing Fabric: ASTM A 1064/A 1064M, steel, welded wire fabric, plain.
b. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

U. Polymer-Concrete, Channel Drainage Systems
1. General Requirements for Polymer-Concrete, Channel Drainage Systems: Modular system of precast, polymer-concrete channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling. Include quantity of units required to form total lengths indicated.
2. Sloped-Invert, Polymer-Concrete Systems:
a. Channel Sections:
1) Interlocking-joint, precast, modular units with end caps.
2) 4-inch (102-mm) inside width and deep, rounded bottom, with built-in invert slope of 0.6 percent and with outlets in quantities, sizes, and locations indicated.
3) Extension sections necessary for required depth.
4) Frame: Include gray-iron or steel frame for grate.
b. Grates:
1) Manufacturer's designation "Heavy **OR** “Medium, **as directed**, Duty," with slots or perforations that fit recesses in channels.
2) Material: Fiberglass **OR** Galvanized steel **OR** Gray iron **OR** Stainless steel, **as directed**.
c. Covers: Solid gray iron if indicated.
d. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.
3. Narrow-Width, Level-Invert, Polymer-Concrete Systems:
a. Channel Sections:
1) Interlocking-joint, precast, modular units with end caps.

2) 5-inch (127-mm) inside width and 9-3/4-inch- (248-mm-) deep, rounded bottom, with level invert and with NPS 4 (DN 100) outlets in quantities, sizes, and locations indicated.

b. Grates:
1) Slots or perforations that fit recesses in channels.
2) Material: Fiberglass **OR** Galvanized steel **OR** Gray iron **OR** Stainless steel, **as directed**.

c. Covers: Solid gray iron if indicated.

d. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.

4. Wide-Width, Level-Invert, Polymer-Concrete Systems:
a. Channel Sections:
1) Interlocking-joint, precast, modular units with end caps.
2) 8-inch (203-mm) inside width and 13-3/4-inch- (350-mm-) deep, rounded bottom, with level invert and with outlets in quantities, sizes, and locations indicated.

b. Grates:
1) Slots or other openings that fit recesses in channels.
2) Material: Fiberglass **OR** Gray iron, **as directed**.

c. Covers: Solid gray iron if indicated.

d. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.

5. Drainage Specialties: Precast, polymer-concrete units.
a. Large Catch Basins:
1) 24-by-12-inch (610-by-305-mm) polymer-concrete body, with outlets in quantities and sizes indicated.
2) Gray-iron slotted grate.
3) Frame: Include gray-iron or steel frame for grate.

b. Small Catch Basins:
1) 19- to 24-inch by approximately 6-inch (483- to 610-mm by approximately 150-mm) polymer-concrete body, with outlets in quantities and sizes indicated.
2) Gray-iron slotted grate.
3) Frame: Include gray-iron or steel frame for grate.

c. Oil Interceptors:
1) Polymer-concrete body with interior baffle and four steel support channels and two 1/4-inch- (6.4-mm-) thick, steel-plate covers.
2) Steel-plate covers.
3) Capacity: 140 gal. (530 L) **OR** 200 gal. (757 L) **OR** 260 gal. (984 L), **as directed**.
4) Inlet and Outlet: NPS 4 (DN 100) **OR** NPS 6 (DN 150), **as directed**.

d. Sediment Interceptors:
1) 27-inch- (686-mm-) square, polymer-concrete body, with outlets in quantities and sizes indicated.
2) 24-inch- (610-mm-) square, gray-iron frame and slotted grate.

6. Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.
7. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

V. Plastic, Channel Drainage Systems
1. General Requirements for Plastic, Channel Drainage Systems:
a. Modular system of plastic channel sections, grates, and appurtenances.
b. Designed so grates fit into frames without rocking or rattling.
c. Number of units required to form total lengths indicated.
2. Fiberglass Systems:
a. Channel Sections:
1) Interlocking-joint, fiberglass modular units, with built-in invert slope of approximately 1 percent and with end caps.
2) Rounded or inclined inside bottom surface, with outlets in quantities, sizes, and locations indicated.

3) Width: 6 inches (150 mm) **OR** 6 or 8 inches (150 or 203 mm) **OR** 8 inches (203 mm), **as directed**.

b. Factory- or field-attached frames that fit channel sections and grates.
1) Material: Galvanized steel **OR** Stainless steel **OR** Manufacturer's standard metal, **as directed**.

c. Grates with slots or perforations that fit frames.
1) Material: Fiberglass **OR** Galvanized steel **OR** Gray iron **OR** Stainless steel, **as directed**.

d. Covers: Solid gray iron if indicated.

e. Drainage Specialties:
1) Large Catch Basins: 24-inch- (610-mm-) square plastic body, with outlets in quantities and sizes indicated. Include gray-iron frame and slotted grate.
2) Small Catch Basins: 12-by-24-inch (305-by-610-mm) plastic body, with outlets in quantities and sizes indicated. Include gray-iron frame and slotted grate.

3. PE Systems:
a. Channel Sections: Interlocking-joint, PE modular units, 4 inches (102 mm) wide, with end caps. Include rounded bottom, with level invert and with outlets in quantities, sizes, and locations indicated.

b. Grates: PE, ladder shaped; with stainless-steel screws.

c. Color: Gray unless otherwise indicated.

d. Drainage Specialties: Include the following PE components:
1) Drains: 4-inch- (102-mm-) diameter, round, slotted top; with NPS 4 (DN 100) bottom outlet.
OR
Drains: 8-inch- (203-mm-) diameter, round, slotted top; with NPS 6 (DN 150) bottom outlet.
OR
Drains: 4-inch- (102-mm-) square, slotted top; with NPS 3 (DN 80) bottom outlet.
OR
Drains: 8-inch- (203-mm-) square, slotted top; with NPS 6 (DN 150) bottom outlet.
OR
Catch Basins: 12-inch- (305-mm-) square plastic body, with outlets in quantities and sizes indicated. Include PE slotted grate 11-3/4 inches (298 mm) square by 1-1/8 inches (28.6 mm) thick.

4. Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.

5. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

W. Catch Basins

1. Standard Precast Concrete Catch Basins:
a. Description: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.

b. Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (102-mm) minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.

c. Riser Sections: 4-inch (102-mm) minimum thickness, 48-inch (1200-mm) diameter, and lengths to provide depth indicated.

d. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.

e. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.

f. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.
OR
Grade Rings: Include two or three reinforced-concrete rings, of 6- to 9-inch (150- to 225-mm) total thickness, that match 24-inch- (610-mm-) diameter frame and grate.

g. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps; FRP ladder; or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of catch basin to finished grade is less than 60 inches (1500 mm).

h. Pipe Connectors: ASTM C 923 (ASTM C 923M), resilient, of size required, for each pipe connecting to base section.

2. Designed Precast Concrete Catch Basins: ASTM C 913, precast, reinforced concrete; designed according to ASTM C 890 for A-16 (ASSHTO HS20-44), heavy-traffic, structural loading; of depth, shape, and dimensions indicated, with provision for joint sealants.
   a. Joint Sealants: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
   b. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.
      OR
      Grade Rings: Include two or three reinforced-concrete rings, of 6- to 9-inch (150- to 225-mm) total thickness, that match 24-inch- (610-mm-) diameter frame and grate.
   c. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps; FRP ladder; or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of catch basin to finished grade is less than 60 inches (1500 mm).
   d. Pipe Connectors: ASTM C 923 (ASTM C 923M), resilient, of size required, for each pipe connecting to base section.
3. Frames and Grates (for rectangular structures): ASTM A 536, Grade 60-40-18, ductile iron designed for A-16, structural loading. Include flat grate with small square or short-slotted drainage openings.
   a. Size: 24 by 24 inches (610 by 610 mm) minimum unless otherwise indicated.
   b. Grate Free Area: Approximately 50 percent unless otherwise indicated.
4. Frames and Grates (for round, manhole-type structures): ASTM A 536, Grade 60-40-18, ductile iron designed for A-16, structural loading. Include 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch (102-mm) minimum width flange, and 26-inch- (660-mm-) diameter flat grate with small square or short-slotted drainage openings.
   a. Grate Free Area: Approximately 50 percent unless otherwise indicated.

X. Stormwater Inlets
1. Curb Inlets: Made with vertical curb opening, of materials and dimensions according to utility standards.
2. Gutter Inlets: Made with horizontal gutter opening, of materials and dimensions according to utility standards. Include heavy-duty frames and grates.
3. Combination Inlets: Made with vertical curb and horizontal gutter openings, of materials and dimensions according to utility standards. Include heavy-duty frames and grates.
4. Frames and Grates: Heavy duty, according to utility standards.

Y. Stormwater Detention Structures
1. Cast-in-Place Concrete, Stormwater Detention Structures: Constructed of reinforced-concrete bottom, walls, and top; designed according to ASTM C 890 for A-16 (AASHTO HS20-44), heavy-traffic, structural loading; of depth, shape, dimensions, and appurtenances indicated.
   a. Ballast: Increase thickness of concrete as required to prevent flotation.
   b. Grade Rings (if required): Include two or three reinforced-concrete rings, of 6- to 9-inch (150- to 229-mm) total thickness, that match 24-inch- (610-mm-) diameter frame and cover.

c. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps; FRP ladder; or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of structure to finished grade is less than 60 inches (1500 mm).

2. Manhole Frames and Covers: ASTM A 536, Grade 60-40-18, ductile-iron castings designed for heavy-duty service. Include 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch (102-mm) minimum width flange, and 26-inch- (660-mm-) diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."

Z. Pipe Outlets
1. Head Walls: Cast-in-place reinforced concrete, with apron and tapered sides.
2. Riprap Basins: Broken, irregularly sized and shaped, graded stone according to NSSGA's "Quarried Stone for Erosion and Sediment Control."
   a. Average Size: NSSGA No. R-3, screen opening 2 inches (51 mm).
   b. Average Size: NSSGA No. R-4, screen opening 3 inches (76 mm).
   c. Average Size: NSSGA No. R-5, screen opening 5 inches (127 mm).
3. Filter Stone: According to NSSGA's "Quarried Stone for Erosion and Sediment Control," No. FS-2, No. 4 screen opening, average-size graded stone.
4. Energy Dissipaters: According to NSSGA's "Quarried Stone for Erosion and Sediment Control," No. A-1, 3-ton (2721-kg) average weight armor stone, unless otherwise indicated.

AA. Dry Wells
1. Description: ASTM C 913, precast, reinforced, perforated concrete rings. Include the following:
   a. Floor: Cast-in-place concrete.
   b. Cover: Liftoff-type concrete cover with cast-in lift rings.
   c. Wall Thickness: 4 inches (102 mm) minimum with 1-inch (25-mm) diameter or 1-by-3-inch- (25-by-76-mm-) maximum slotted perforations arranged in rows parallel to axis of ring.
      1) Total Free Area of Perforations: Approximately 15 percent of ring interior surface.
      2) Ring Construction: Designed to be self-aligning.
   d. Filtering Material: ASTM D 448, Size No. 24, 3/4- to 2-1/2-inch (19- to 63-mm) washed, crushed stone or gravel.

   OR

   Description: Manufactured PE side panels and top cover that assemble into 50-gal. (190-L) storage capacity units.
   a. Side Panels: With knockout ports for piping and seepage holes.
   b. Top Cover: With knockout port for drain.
   c. Filter Fabric: As recommended by unit manufacturer.
   d. Filtering Material: ASTM D 448, Size No. 24, 3/4- to 2-1/2-inch (19- to 63-mm) washed, crushed stone or gravel.

   OR

   Description: Constructed-in-place aggregate type. Include the following:
   a. Lining: Clay or concrete bricks.

      OR

      Lining: Concrete blocks or precast concrete rings with notches or weep holes.
   b. Filtering Material: ASTM D 448, Size No. 24, 3/4- to 2-1/2-inch (19- to 63-mm) washed, crushed stone or gravel.
   c. Cover: Precast, reinforced-concrete slab, designed for structural loading according to ASTM C 890 and made according to ASTM C 913. Include slab dimensions that will extend 12 inches (300 mm) minimum beyond edge of excavation, with bituminous coating over entire surface. Cast cover with opening for manhole in center.
   d. Manhole: 24-inch- (610-mm-) diameter, reinforced-concrete access lid with steel lift rings. Include bituminous coating over entire surface.

BB. Stormwater Disposal Systems

1. Chamber Systems:

a. Storage and Leaching Chambers: Molded PE with perforated sides and open bottom. Include number of chambers, distribution piping, end plates, and other standard components as required for system total capacity.

b. Filtering Material: ASTM D 448, Size No. 24, 3/4- to 2-1/2-inch (19- to 63-mm) washed, crushed stone or gravel.

c. Filter Mat: Geotextile woven or spun filter fabric, in one or more layers, for minimum total unit weight of 4 oz./sq. yd. (135 g/sq. m).

OR

Pipe Systems: Perforated manifold, header, and lateral piping complying with AASHTO M 252M for NPS 10 (DN 250) and smaller, AASHTO M 294M for NPS 12 to NPS 60 (DN 300 to DN 1500). Include proprietary fittings, couplings, seals, and filter fabric.

1.3 EXECUTION

1.4 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Division 31 Section "Earth Moving".

B. Piping Installation

1. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
2. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
3. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
4. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
5. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.
6. Install gravity-flow, nonpressure drainage piping according to the following:

a. Install piping pitched down in direction of flow.

b. Install piping NPS 6 (DN 150) and larger with restrained joints at tee fittings and at changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place concrete supports or anchors.

c. Install piping with 36-inch (915-mm) **OR** 48-inch (1220-mm) **OR** 60-inch (1520-mm) **OR** 72-inch (1830-mm), **as directed**, minimum cover.

d. Install hub-and-spigot, cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook."

e. Install hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook."

f. Install ductile-iron piping and special fittings according to AWWA C600 or AWWA M41.

g. Install corrugated steel piping according to ASTM A 798/A 798M.

h. Install corrugated aluminum piping according to ASTM B 788/B 788M.

i. Install ABS sewer piping according to ASTM D 2321 and ASTM F 1668.

j. Install PE corrugated sewer piping according to ASTM D 2321.

k. Install PVC cellular-core piping according to ASTM D 2321 and ASTM F 1668.

l. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.

m. Install PVC profile gravity sewer piping according to ASTM D 2321 and ASTM F 1668.

n. Install PVC water-service piping according to ASTM D 2321 and ASTM F 1668.
o. Install fiberglass sewer piping according to ASTM D 3839 and ASTM F 1668.
p. Install nonreinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."
q. Install reinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."

7. Install force-main pressure piping according to the following:
   a. Install piping with restrained joints at tee fittings and at horizontal and vertical changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place concrete supports or anchors.
   b. Install piping with 36-inch (915-mm) **OR** 48-inch (1220-mm) **OR** 60-inch (1520-mm) **OR** 72-inch (1830-mm), **as directed**, minimum cover.
   c. Install **ductile**-iron pressure piping according to AWWA C600 or AWWA M41.
   d. Install ductile-iron special fittings according to AWWA C600.
   e. Install PVC pressure piping according to AWWA M23, or ASTM D 2774 and ASTM F 1668.
   f. Install PVC water-service piping according to ASTM D 2774 and ASTM F 1668.
8. Install corrosion-protection piping encasement over the following underground metal piping according to ASTM A 674 or AWWA C105:
   a. Hub-and-spigot, cast-iron soil pipe and fittings.
   b. Hubless cast-iron soil pipe and fittings.
   c. Ductile-iron pipe and fittings.
   d. Expansion joints and deflection fittings.

C. Pipe Joint Construction
1. Join gravity-flow, nonpressure drainage piping according to the following:
   a. Join hub-and-spigot, cast-iron soil piping with gasketed joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
   b. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
   c. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
   d. Join ductile-iron culvert piping according to AWWA C600 for push-on joints.
   e. Join ductile-iron piping and special fittings according to AWWA C600 or AWWA M41.
   f. Join corrugated steel sewer piping according to ASTM A 798/A 798M.
   g. Join corrugated aluminum sewer piping according to ASTM B 788/B 788M.
   h. Join ABS sewer piping according to ASTM D 2321 and ASTM D 2751 for elastomeric-seal joints.
   i. Join corrugated PE piping according to ASTM D 3212 for push-on joints.
   j. Join PVC cellular-core piping according to ASTM D 2321 and ASTM F 891 for solvent-cemented joints.
   k. Join PVC corrugated sewer piping according to ASTM D 2321 for elastomeric-seal joints.
   l. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasketed joints.
   m. Join PVC profile gravity sewer piping according to ASTM D 2321 for elastomeric-seal joints or ASTM F 794 for gasketed joints.
   n. Join fiberglass sewer piping according to ASTM D 3839 for elastomeric-seal joints.
   o. Join nonreinforced-concrete sewer piping according to ASTM C 14 (ASTM C 14M) and ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
   p. Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
   q. Join dissimilar pipe materials with nonpressure-type flexible couplings.
2. Join force-main pressure piping according to the following:
   a. Join ductile-iron pressure piping according to AWWA C600 or AWWA M41 for push-on joints.

b. Join ductile-iron special fittings according to AWWA C600 or AWWA M41 for push-on joints.
c. Join PVC pressure piping according to AWWA M23 for gasketed joints.
d. Join PVC water-service piping according to ASTM D 2855 for solvent-cemented joints.
e. Join dissimilar pipe materials with pressure-type couplings.

D. Backwater Valve Installation
1. Install horizontal-type backwater valves in piping where indicated.
2. Install combination horizontal and manual gate-valve type in piping and in manholes where indicated.
3. Install terminal-type backwater valves on end of piping and in manholes where indicated.

E. Cleanout Installation
1. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
a. Use Light-Duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
b. Use Medium-Duty, top-loading classification cleanouts in paved foot-traffic areas.
c. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.
d. Use Extra-Heavy-Duty, top-loading classification cleanouts in roads.
e. Set cleanout frames and covers in earth in cast-in-place concrete block, 18 by 18 by 12 inches (450 by 450 by 300 mm) deep. Set with tops 1 inch (25 mm) above surrounding earth grade.
f. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

F. Drain Installation
1. Install type of drains in locations indicated.
a. Use Light-Duty, top-loading classification drains in earth or unpaved foot-traffic areas.
b. Use Medium-Duty, top-loading classification drains in paved foot-traffic areas.
c. Use Heavy-Duty, top-loading classification drains in vehicle-traffic service areas.
d. Use Extra-Heavy-Duty, top-loading classification drains in roads.
2. Embed drains in 4-inch (102-mm) minimum concrete around bottom and sides.
3. Fasten grates to drains if indicated.
4. Set drain frames and covers with tops flush with pavement surface.
5. Assemble trench sections with flanged joints.
6. Embed trench sections in 4-inch (102-mm) minimum concrete around bottom and sides.

G. Manhole Installation
1. General: Install manholes, complete with appurtenances and accessories indicated.
2. Install precast concrete manhole sections with sealants according to ASTM C 891.
3. Where specific manhole construction is not indicated, follow manhole manufacturer's written instructions.
4. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches (76 mm) above finished surface elsewhere unless otherwise indicated.

H. Catch Basin Installation
1. Construct catch basins to sizes and shapes indicated.
2. Set frames and grates to elevations indicated.

I. Stormwater Inlet And Outlet Installation
1. Construct inlet head walls, aprons, and sides of reinforced concrete, as indicated.
2. Construct riprap of broken stone, as indicated.
3. Install outlets that spill onto grade, anchored with concrete, where indicated.
4. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.
5. Construct energy dissipaters at outlets, as indicated.

J. Dry Well Installation
1. Excavate hole to diameter of at least 6 inches (150 mm) greater than outside of dry well. Do not extend excavation into ground-water table.
2. Install precast, concrete-ring dry wells according to the following:
   a. Assemble rings to depth indicated.
   b. Extend rings to height where top of cover will be approximately 8 inches (203 mm) below finished grade.
   c. Backfill bottom of inside of rings with filtering material to level at least 12 inches (300 mm) above bottom.
   d. Extend effluent inlet pipe 12 inches (300 mm) into rings and terminate into side of tee fitting.
   e. Backfill around outside of rings with filtering material to top level of rings.
   f. Install cover over top of rings.
3. Install manufactured, PE dry wells according to manufacturer's written instructions and the following:
   a. Assemble and install panels and cover.
   b. Backfill bottom of inside of unit with filtering material to level at least 12 inches (300 mm) above bottom.
   c. Extend effluent inlet pipe 12 inches (300 mm) into unit and terminate into side of tee fitting.
   d. Install filter fabric around outside of unit.
   e. Install filtering material around outside of unit.
4. Install constructed-in-place dry wells according to the following:
   a. Install brick lining material dry and laid flat, with staggered joints for seepage. Build to diameter and depth indicated.
   b. Install block lining material dry, with staggered joints and 20 percent minimum of blocks on side for seepage. Install precast concrete rings with notches or weep holes for seepage. Build to diameter and depth indicated.
   c. Extend lining material to height where top of manhole will be approximately 8 inches (203 mm) below finished grade.
   d. Backfill bottom of inside of lining with filtering material to level at least 12 inches (300 mm) above bottom.
   e. Extend effluent inlet pipe 12 inches (300 mm) into lining and terminate into side of tee fitting.
   f. Backfill around outside of lining with filtering material to top level of lining.
   g. Install manhole over top of dry well. Support cover on undisturbed soil. Do not support cover on lining.

K. Concrete Placement
1. Place cast-in-place concrete according to ACI 318.

L. Channel Drainage System Installation
1. Install with top surfaces of components, except piping, flush with finished surface.
2. Assemble channel sections to form slope down toward drain outlets. Use sealants, adhesives, fasteners, and other materials recommended by system manufacturer.
3. Embed channel sections and drainage specialties in 4-inch (102-mm) minimum concrete around bottom and sides.
4. Fasten grates to channel sections if indicated.
5. Assemble channel sections with flanged or interlocking joints.
6. Embed channel sections in 4-inch (102-mm) minimum concrete around bottom and sides.

M. Stormwater Disposal System Installation
1. Chamber Systems: Excavate trenches of width and depth, and install system and backfill according to chamber manufacturer's written instructions. Include storage and leaching chambers, filtering material, and filter mat.
   OR

Piping Systems: Excavate trenches of width and depth, and install piping system, filter fabric, and backfill, according to piping manufacturer's written instructions.

N. Connections
1. Connect nonpressure, gravity-flow drainage piping in building's storm building drains specified in Division 22 Section "Facility Storm Drainage Piping".
2. Connect force-main piping to building's storm drainage force mains specified in Division 22 Section "Facility Storm Drainage Piping". Terminate piping where indicated.
3. Make connections to existing piping and underground manholes.
   a. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting, plus 6-inch (150-mm) overlap, with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
   b. Make branch connections from side into existing piping, NPS 4 to NPS 20 (DN 100 to DN 500). Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
   c. Make branch connections from side into existing piping, NPS 21 (DN 525) or larger, or to underground manholes and structures by cutting into existing unit and creating an opening large enough to allow 3 inches (76 mm) of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall unless otherwise indicated. On outside of pipe, manhole, or structure wall, encase entering connection in 6 inches (150 mm) of concrete for minimum length of 12 inches (300 mm) to provide additional support of collar from connection to undisturbed ground.
      1) Use concrete that will attain a minimum 28-day compressive strength of 3000 psi (20.7 MPa) unless otherwise indicated.
      2) Use epoxy-bonding compound as interface between new and existing concrete and piping materials.
   d. Protect existing piping, manholes, and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.
4. Connect to sediment interceptors specified in Division 22 Section "Sanitary Waste Interceptors".
5. Pipe couplings, expansion joints, and deflection fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
   a. Use nonpressure-type flexible couplings where required to join gravity-flow, nonpressure sewer piping unless otherwise indicated.
      1) Unshielded **OR** Shielded, **as directed**, flexible couplings for same or minor difference OD pipes.
      2) Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.
      3) Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.
   b. Use pressure-type pipe couplings for force-main joints.

O. Closing Abandoned Storm Drainage Systems
1. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:
   a. Close open ends of piping with at least 8-inch- (203-mm-) thick, brick masonry bulkheads.
   b. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.
2. Abandoned Manholes and Structures: Excavate around manholes and structures as required and use one procedure below:
   a. Remove manhole or structure and close open ends of remaining piping.

b. Remove top of manhole or structure down to at least 36 inches (915 mm) below final grade. Fill to within 12 inches (300 mm) of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.

3. Backfill to grade according to Division 31 Section "Earth Moving".

P. Identification

1. Materials and their installation are specified in Division 31 Section "Earth Moving". Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.
   a. Use warning tape **OR** detectable warning tape, **as directed**, over ferrous piping.
   b. Use detectable warning tape over nonferrous piping and over edges of underground structures.

Q. Field Quality Control

1. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (610 mm) of backfill is in place, and again at completion of Project.
   a. Submit separate reports for each system inspection.
   b. Defects requiring correction include the following:
      1) Alignment: Less than full diameter of inside of pipe is visible between structures.
      2) Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
      3) Damage: Crushed, broken, cracked, or otherwise damaged piping.
      4) Infiltration: Water leakage into piping.
      5) Exfiltration: Water leakage from or around piping.
   c. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
   d. Reinspect and repeat procedure until results are satisfactory.
2. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
   a. Do not enclose, cover, or put into service before inspection and approval.
   b. Test completed piping systems according to requirements of authorities having jurisdiction.
   c. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
   d. Submit separate report for each test.
   e. Gravity-Flow Storm Drainage Piping: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:
      1) Exception: Piping with soiltight joints unless required by authorities having jurisdiction.
      2) Option: Test plastic piping according to ASTM F 1417.
      3) Option: Test concrete piping according to ASTM C 924 (ASTM C 924M).
   f. Force-Main Storm Drainage Piping: Perform hydrostatic test after thrust blocks, supports, and anchors have hardened. Test at pressure not less than 1-1/2 times the maximum system operating pressure, but not less than 150 psig (1035 kPa).
      1) Ductile-Iron Piping: Test according to AWWA C600, "Hydraulic Testing" Section.
      2) PVC Piping: Test according to AWWA M23, "Testing and Maintenance" Chapter.
3. Leaks and loss in test pressure constitute defects that must be repaired.
4. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

R. Cleaning

1. Clean interior of piping of dirt and superfluous materials. Flush with potable water **OR** Flush with water, **as directed**.

END OF SECTION 33 42 11 00

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Task	Specification	Specification Description
33 42 11 00	21 05 23 00	Piped Utilities Basic Materials And Methods
33 42 11 00	33 14 13 23	Sand Drains
33 42 11 00	13 12 13 00	Water Distribution
33 42 11 00	22 05 76 00	Sanitary Sewerage
33 42 11 00	33 14 13 23b	Ground-Loop Heat-Pump Piping
33 42 11 00	31 05 13 00	Subdrainage
33 42 11 00	22 11 16 00b	Storm Drainage Piping
33 42 11 00	22 05 76 00a	Storm Drainage Piping Specialties

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SECTION 33 42 13 13 - CULVERTS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for culverts. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: For each type of product indicated.

C. Delivery, Storage, And Handling
1. Delivery and Storage: Materials delivered to site shall be inspected for damage, unloaded, and stored with a minimum of handling. Materials shall not be stored directly on the ground. The inside of pipes and fittings shall be kept free of dirt and debris. Before, during, and after installation, plastic pipe and fittings shall be protected from any environment that would result in damage or deterioration to the material. The Contractor shall have a copy of the manufacturer's instructions available at the construction site at all times and shall follow these instructions unless directed otherwise by the the Owner. Solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install plastic pipe shall be stored in accordance with the manufacturer's recommendations and shall be discarded if the storage period exceeds the recommended shelf life. Solvents in use shall be discarded when the recommended pot life is exceeded.
2. Handling: Materials shall be handled in a manner that ensures delivery to the trench in sound, undamaged condition. Pipe shall be carried to the trench, not dragged.

1.2 PRODUCTS

A. Pipe For Culverts
1. Pipe for culverts and storm drains shall be of the sizes indicated and shall conform to the requirements specified.
2. Concrete Pipe
a. ASTM C76/ASTM C76M, Class I **OR** II **OR** III **OR** IV **OR** V, **as directed**, or ASTM C655 D-Load. Note: D-load is defined as the minimum required three-edge test load on a pipe to produce a 0.01 inch crack and/or ultimate failure in pounds per linear foot per foot (no metric definition) of inside diameter.
b. Reinforced Arch Culvert and Storm Drainpipe: ASTM C506/ASTM C506M, Class A-II **OR** A-III **OR** A-IV, **as directed**.
c. Reinforced Elliptical Culvert and Storm Drainpipe: ASTM C507/ASTM C507M. Horizontal elliptical pipe shall be Class HE-A **OR** HE-I **OR** HE-II **OR** HE-III **OR** HE-IV, **as directed**. Vertical elliptical pipe shall be Class VE-II **OR** VE-III **OR** VE-IV **OR** VE-V **OR** VE-VI, **as directed**.
d. Nonreinforced Pipe: ASTM C14/ASTM C14M, Class 1 **OR** 2 **OR** 3, **as directed**.
1) Cast-In-Place Nonreinforced Conduit: ACI 346, except that testing shall be the responsibility of and at the expense of the Contractor. In the case of other conflicts between ACI 346 and project specifications, requirements of ACI 346 shall govern.
NOTE: This type conduit should not be used beneath structures, for drain crossings, adjacent to paved areas, or under high fills.
3. Clay Pipe: Standard or extra strength, as indicated, conforming to ASTM C700.
NOTE: "Bell-and-spigot piping only" in areas where corrosion problems may be anticipated with the stainless steel parts of the couplings used for plain-end piping.

4. Corrugated Steel Pipe
   a. ASTM A760/A760M, zinc or aluminum (Type 2) coated pipe of either:
      1) Type I **OR** II, **as directed**, pipe with annular **OR** helical, **as directed**, 2-2/3 by 1/2 inch (68 by 13 mm) corrugations.
      2) Type IR **OR** IIR, **as directed**, pipe with helical 3/4 by 3/4 by 7-1/2 inch (19 by 19 by 190 mm) corrugations.
   b. Fully Bituminous Coated
      1) AASHTO M190 Type A and ASTM A760/A 760M zinc or aluminum (Type 2) coated pipe of either:
         a) Type I **OR** II, **as directed**, pipe with annular **OR** helical, **as directed**, 2-2/3 by 1/2 inch (68 by 13 mm) corrugations.
         b) Type IR **OR** IIR, **as directed**, pipe with helical 3/4 by 3/4 by 7-1/2 inch (19 by 19 by 190 mm) corrugations.
   c. Half Bituminous Coated, Part Paved: AASHTO M190 Type B and ASTM A760/A 760M zinc or aluminum (Type 2) coated Type I **OR** II, **as directed**, pipe with annular **OR** helical, **as directed**, 2-2/3 by 1/2 inch (68 by 13 mm) corrugations.
   d. Fully Bituminous Coated, Part Paved: AASHTO M190 Type C and ASTM A760/A 760M zinc or aluminum (Type 2) coated Type I **OR** II, **as directed**, pipe with annular **OR** helical, **as directed**, 2-2/3 by 1/2 inch (68 by 13 mm) corrugations.
   e. Fully Bituminous Coated, Fully Paved: AASHTO M190 Type D and ASTM A760/A 760M zinc or aluminum (Type 2) coated Type I **OR** II, **as directed**, pipe with annular **OR** helical, **as directed**, 2-2/3 by 1/2 inch (68 by 13 mm) corrugations.
   f. Concrete-Lined: ASTM A760/A760M zinc coated Type I corrugated steel pipe with annular **OR** helical, **as directed**, 2-2/3 by 1/2 inch (68 by 13 mm) corrugations and a concrete lining in accordance with ASTM A849.
   g. Polymer Precoated: ASTM A 762/A 762M corrugated steel pipe fabricated from ASTM A742/A742M Grade 250/250 10/10 polymer precoated sheet of either:
      1) Type I **OR** II, **as directed**, pipe with annular **OR** helical, **as directed**, 2-2/3 by 1/2 inch (68 by 13 mm) corrugations.
      2) Type IR **OR** IIR, **as directed**, pipe with helical 3/4 by 3/4 by 7-1/2 inch (19 by 19 by 190 mm) corrugations.
   h. Polymer Precoated, Part Paved: ASTM A762/A762M Type I **OR** II, **as directed**, corrugated steel pipe and AASHTO M190 Type B (modified) paved invert only, fabricated from ASTM A742/A742M Grade 250/250 10/10 polymer precoated sheet with annular **OR** helical, **as directed**, 2-2/3 by 1/2 inch (68 by 13 mm) corrugations.
   i. Polymer Precoated, Fully Paved: ASTM A762/A762M Type I **OR** II, **as directed**, corrugated steel pipe and AASHTO M190 Type D (modified), fully paved only, fabricated from ASTM A 742/A 742M Grade 250/250 10/10 polymer precoated sheet with annular **OR** helical, **as directed**, 2-2/3 by 1/2 inch (68 by 13 mm) corrugations.
5. Corrugated Aluminum Alloy Pipe: ASTM B745/B745M corrugated aluminum alloy pipe of either:
   1) Type I **OR** II, **as directed**, pipe with annular **OR** helical, **as directed**, corrugations.
   2) Type IA **OR** IR **OR** IIA **OR** IIR, **as directed**, pipe with helical corrugations.
   b. Aluminum Fully Bituminous Coated: Bituminous coating shall conform to ASTM A849. Piping shall conform to AASHTO M190 Type A and ASTM B745/B745M corrugated aluminum alloy pipe of either:
      1) Type I **OR** II, **as directed**, pipe with annular **OR** helical, **as directed**, corrugations.
      2) Type IA **OR** IR **OR** IIA **OR** IIR, **as directed**, pipe with helical corrugations.
   c. Aluminum Fully Bituminous Coated, Part Paved: Bituminous coating shall conform to ASTM A849. Piping shall conform to AASHTO M190 Type C and ASTM B 745/B 745M corrugated aluminum alloy pipe of either:
      1) Type I **OR** II, **as directed**, pipe with annular **OR** helical, **as directed**, corrugations.
      2) Type IR **OR** IIR, **as directed**, pipe with helical corrugations.
6. Structural Plate, Steel Pipe, Pipe Arches and Arches

a. Assembled with galvanized steel nuts and bolts, from galvanized corrugated steel plates conforming to AASHTO M167. Pipe coating, when required, shall conform to the requirements of AASHTO M190 Type A **OR** AASHTO M243, **as directed**.
b. Thickness of plates shall be as indicated.

7. Structural Plate, Aluminum Pipe, Pipe Arches and Arches
   a. Assembled with either aluminum alloy, aluminum coated steel, stainless steel or zinc coated steel nuts and bolts. Nuts and bolts, and aluminum alloy plates shall conform to AASHTO M219. Pipe coating, when required, shall conform to the requirements of AASHTO M190, Type A **OR** AASHTO M 243, **as directed**.
   b. Thickness of plates shall be as indicated.
8. Ductile Iron Culvert Pipe: ASTM A716.
9. Cast-Iron Soil Piping: Cast-Iron Soil Pipe shall conform to ASTM A74, service-weight; gaskets shall be compression-type rubber conforming to ASTM C564.
10. PVC Pipe
    a. The pipe manufacturer's resin certification, indicating the cell classification of PVC used to manufacture the pipe, shall be submitted prior to installation of the pipe.
    b. Type PSM PVC Pipe: ASTM D3034, Type PSM, maximum SDR 35, produced from PVC certified by the compounder as meeting the requirements of ASTM D1784, minimum cell class 12454-B.
    c. Profile PVC Pipe: ASTM F794, Series 46, produced from PVC certified by the compounder as meeting the requirements of ASTM D1784, minimum cell class 12454-B.
    d. Smooth Wall PVC Pipe: ASTM F679 produced from PVC certified by the compounder as meeting the requirements of ASTM D1784, minimum cell class 12454-B.
    e. Corrugated PVC Pipe: ASTM F949 produced from PVC certified by the compounder as meeting the requirements of ASTMD 1784, minimum cell class 12454-B.
11. PE Pipe
    a. The pipe manufacturer's resin certification indicating the cell classification of PE used to manufacture the pipe shall be submitted prior to installation of the pipe. The minimum cell classification for polyethylene plastic shall apply to each of the seven primary properties of the cell classification limits in accordance with ASTM D3350.
    b. Smooth Wall PE Pipe: ASTM F714, maximum DR of 21 for pipes 3 to 24 inches (80 to 600 mm) in diameter and maximum DR of 26 for pipes 26 to 48 inches (650 to 1200 mm) in diameter. Pipe shall be produced from PE certified by the resin producer as meeting the requirements of ASTM D3350, minimum cell class 335434C.
    c. Corrugated PE Pipe: AASHTO M294, Type S or D, for pipes 12 to 48 inches (300 to 1200 mm) and AASHTO MP 7, Type S or D, for pipes 54 to 60 inches (1350 to 1500 mm) produced from PE certified by the resin producer as meeting the requirements of ASTM D3350, minimum cell class in accordance with AASHTO M294. Pipe walls shall have the following properties:
       NOTE: Corrugated PE pipe culverts and storm drains shall not be installed beneath airfield pavements, Class A, B, or C roads, or road pavements with a design index of 6 or greater. Type S pipe has a full circular cross-section, with an outer corrugated pipe wall and a smooth inner liner. Type C pipe has a full circular cross-section, with a corrugated surface both inside and outside. Corrugations may be either annular or helical.

Nominal Size (in.)	Minimum Wall Area (square in/ft)	Minimum Moment of Inertia of Wall Section (in to the 4th/in)
12	1.50	0.024
15	1.91	0.053
18	2.34	0.062
24	3.14	0.116
30	3.92	0.163
36	4.50	0.222
42	4.69	0.543

48	5.15	0.543
54	5.67	0.800
60	6.45	0.800

Nominal Size (mm)	Minimum Wall Area (square mm/m)	Minimum Moment of Inertia of Wall Section (mm to the 4th/mm)
300	3200	390
375	4000	870
450	4900	1020
600	6600	1900
750	8300	2670
900	9500	3640
1050	9900	8900
1200	10900	8900
1350	12000	13110
1500	13650	13110

d. Profile Wall PE Pipe: ASTM F894, RSC 160, produced from PE certified by the resin producer as meeting the requirements of ASTM D3350, minimum cell class 334433C. Pipe walls shall have the following properties:

Nominal Size (in.)	Minimum Wall Area (square in/ft)	Minimum Moment Of Inertia of Wall Section (in to the 4th/in) Cell Class 334433C	Cell Class 335434C
18	2.96	0.052	0.038
21	4.15	0.070	0.051
24	4.66	0.081	0.059
27	5.91	0.125	0.091
30	5.91	0.125	0.091
33	6.99	0.161	0.132
36	8.08	0.202	0.165
42	7.81	0.277	0.227
48	8.82	0.338	0.277

Nominal Size (mm)	Minimum Wall Area (square mm/m)	Minimum Moment Of Inertia of Wall Section (mm to the 4th/mm) Cell Class 334433C	Cell Class 335434C
450	6300	850	620
525	8800	1150	840
600	9900	1330	970
675	12500	2050	1490
750	12500	2050	1490

825	14800	2640	2160
900	17100	3310	2700
1050	16500	4540	3720
1200	18700	5540	4540

B. Drainage Structures
1. Flared End Sections: Sections shall be of a standard design fabricated from zinc coated steel sheets meeting requirements of ASTM A929/A929M.
2. Precast Reinforced Concrete Box: Four-sided box section with open ends to be monolithically cast of reinforced concrete, smooth inside surfaces. Each box section shall be manufactured with chamfered inside corners. Design and manufacture shall conform to ASTM C890.
   a. Design References: ACI 318.
      1) Boxes subjected to highway loadings shall conform to requirements of AASHTO M259 or M273, as applicable, and ASTM C789, C850, C1433, and PS62.
      2) Boxes subjected to aircraft loadings shall conform to requirements of FAA specifications.
      3) Boxes subjected to railway loadings shall conform to requirements of AREMA specifications.
   b. Concrete: 5,000 psi @ 30 days, unless otherwise directed.
   c. Entrained Air: 5 to 9 percent.
   d. Steel Reinforcing: ASTM A1064, A615, A616, Grade 60, 60 ksi.
   e. Design Loading: AASHTO HS-20-44 or HS-25-44 with 30 percent impact and equivalent soil pressure of 130 psf. Floatation forces not accounted for.
   f. Joints: Each section shall have a male and female end with no less than 1-1/2-inch of concrete overlap and shall include a 1-inch square neoprene gasket, cemented to male surface of section during manufacture.
   g. End Sections: As required for the individual installation, provide:
      1) Doweled end for 1-inch diameter x 12-inch deep steel dowels, keyway slot.
      2) Keyway slot, a shear connection between the precast and field cast sections.
      3) Plain end, for use where wing and end walls act independently of precast box.
   h. Lifting Pins: Each section shall be equipped with 4 OSHA approved lifting pins.
   i. For multi-cell installations, fill 1-inch spacing between cells with granular material to assume proper load distribution.
3. Three-Sided Structures for Culverts or Short Span Bridge System
   a. Structures shall conform to requirements of ASTM C1504 and ACI 318. For structures subjected to roadway loadings, conform to requirements of AASHTO specifications.

C. Miscellaneous Materials
1. Concrete
   a. Unless otherwise specified, concrete and reinforced concrete shall conform to the requirements concrete under Division 03 Section "Cast-in-place Concrete". The concrete mixture shall have air content by volume of concrete, based on measurements made immediately after discharge from the mixer, of 5 to 7 percent when maximum size of coarse aggregate exceeds 1-1/2 inches (37.5 mm).
   b. Air content shall be determined in accordance with ASTM C231. The concrete covering over steel reinforcing shall not be less than 1 inch (25 mm) thick for covers and not less than 1-1/2 inches (40 mm) thick for walls and flooring. Concrete covering deposited directly against the ground shall have a thickness of at least 3 inches (75 mm) between steel and ground.
   c. Expansion-joint filler material shall conform to ASTM D1751, or ASTM D1752, or shall be resin-impregnated fiberboard conforming to the physical requirements of ASTM D1752.
2. Mortar: Mortar for pipe joints, connections to other drainage structures, and brick or block construction shall conform to ASTM C270, Type M, except that the maximum placement time shall be 1 hour. The quantity of water in the mixture shall be sufficient to produce a stiff workable mortar. Water shall be clean and free of harmful acids, alkalies, and organic impurities. The mortar shall be used within 30 minutes after the ingredients are mixed with water. The inside of

the joint shall be wiped clean and finished smooth. The mortar head on the outside shall be protected from air and sun with a proper covering until satisfactorily cured.

3. Precast Concrete Segmental Blocks: Precast concrete segmental block shall conform to ASTM C139, not more than 8 inches (200 mm) thick, not less than 8 inches (200 mm) long, and of such shape that joints can be sealed effectively and bonded with cement mortar.
4. Brick
   a. Brick shall conform to ASTM C62, Grade SW; ASTM C55, Grade S-I or S-II; or ASTM C32, Grade MS. Mortar for jointing and plastering shall consist of one part portland cement and two parts fine sand. Lime may be added to the mortar in a quantity not more than 25 percent of the volume of cement.
   b. The joints shall be filled completely and shall be smooth and free from surplus mortar on the inside of the structure. Brick structures shall be plastered with 1/2 inch (10 mm) of mortar over the entire outside surface of the walls. For square or rectangular structures, brick shall be laid in stretcher courses with a header course every sixth course. For round structures, brick shall be laid radially with every sixth course a stretcher course.
5. Precast Reinforced Concrete Manholes
   a. Precast reinforced concrete manholes shall conform to ASTM C478/ASTM C478M.
   b. Joints between precast concrete risers and tops shall be full-bedded in cement mortar and shall be smoothed to a uniform surface on both interior and exterior of the structure **OR** made with flexible watertight, rubber-type gaskets meeting the requirements of paragraph JOINTS, **as directed**.
6. Prefabricated Corrugated Metal Manholes
   a. Manholes shall be of the type and design recommended by the manufacturer.
   b. Manholes shall be complete with frames and cover, or frames and gratings.
7. Frame and Cover for Gratings
   a. Frame and cover for gratings shall be cast gray iron, ASTM A48/A48M,
   b. Class 35B; cast ductile iron, ASTM A536, Grade 65-45-12; or cast aluminum, ASTM B26M/B26, Alloy 356.OT6. Weight, shape, size, and waterway openings for grates and curb inlets shall be as indicated on the plans.
8. Joints
   a. Flexible Watertight Joints
      1) Materials: Flexible watertight joints shall be made with plastic or rubber-type gaskets for concrete pipe and with factory-fabricated resilient materials for clay pipe. The design of joints and the physical requirements for plastic gaskets shall conform to AASHTO M198, and rubber-type gaskets shall conform to ASTM C443/ASTM C443M. Factory-fabricated resilient joint materials shall conform to ASTM C425. Gaskets shall have not more than one factory-fabricated splice, except that two factory-fabricated splices of the rubber-type gasket are permitted if the nominal diameter of the pipe being gasketed exceeds 54 inches (1.35 m).
      2) Test Requirements: Watertight joints shall be tested and shall meet test requirements of paragraph HYDROSTATIC TEST ON WATERTIGHT JOINTS. Rubber gaskets shall comply with the oil resistant gasket requirements of ASTM C443/ASTM C443M. Certified copies of test results shall be delivered to the the Owner before gaskets or jointing materials are installed. Alternate types of watertight joint may be furnished, if specifically approved.
   b. External Sealing Bands: Requirements for external sealing bands shall conform to ASTM C877/ASTM C877M.
   c. Flexible Watertight, Gasketed Joints
      1) Gaskets: When infiltration or exfiltration is a concern for pipe lines, the couplings may be required to have gaskets. The closed-cell expanded rubber gaskets shall be a continuous band approximately 7 inches (178 mm) wide and approximately 3/8 inch (10 mm) thick, meeting the requirements of ASTM D1056, Type 2 A1 **OR** B3, **as directed**, and shall have a quality retention rating of not less than 70 percent when tested for weather resistance by ozone chamber exposure, Method B of ASTM D1171. Rubber O-ring gaskets shall be 13/16 inch (21 mm) in diameter for pipe

diameters of 36 inches (914 mm) or smaller and 7/8 inch (22 mm) in diameter for larger pipe having 1/2 inch (13 mm) deep end corrugation. Rubber O-ring gaskets shall be 1-3/8 inches (35 mm) in diameter for pipe having 1 inch (25 mm) deep end corrugations. O-rings shall meet the requirements of AASHTO M198 or ASTM C443/ASTM C443M. Flexible plastic gaskets shall conform to requirements of AASHTO M198, Type B.

2) Connecting Bands: Connecting bands shall be of the type, size and sheet thickness of band, and the size of angles, bolts, rods and lugs as indicated or where not indicated as specified in the applicable standards or specifications for the pipe. Exterior rivet heads in the longitudinal seam under the connecting band shall be countersunk or the rivets shall be omitted and the seam welded. Watertight joints shall be tested and shall meet the test requirements of paragraph HYDROSTATIC TEST ON WATERTIGHT JOINTS.

d. PVC Plastic Pipes: Joints shall be solvent cement or elastomeric gasket type in accordance with the specification for the pipe and as recommended by the pipe manufacturer.

e. Smooth Wall PE Plastic Pipe: Pipe shall be joined using butt fusion method as recommended by the pipe manufacturer.

f. Corrugated PE Plastic Pipe: Water tight joints shall be made using a PVC or PE coupling and rubber gaskets as recommended by the pipe manufacturer. Rubber gaskets shall conform to ASTM F477. Soil tight joints shall conform to the requirements in AASHTO HB-17, Division II, Section 26.4.2.4.(e) for soil tightness and shall be as recommended by the pipe manufacturer.

g. Profile Wall PE Plastic Pipe: Joints shall be gasketed or thermal weld type with integral bell in accordance with ASTM F894.

h. Ductile Iron Pipe: Couplings and fittings shall be as recommended by the pipe manufacturer.

D. Steel Ladder

1. Steel ladder shall be provided where the depth of the manhole exceeds 12 feet (3.66 m). These ladders shall be not less than 16 inches (406 mm) in width, with 3/4 inch (19 mm) diameter rungs spaced 12 inches (305 mm) apart. The two stringers shall be a minimum 3/8 inch (10 mm) thick and 2-1/2 inches (63 mm) wide. Ladders and inserts shall be galvanized after fabrication in conformance with ASTM A123/A123M.

E. Resilient Connectors

1. Flexible, watertight connectors used for connecting pipe to manholes and inlets shall conform to ASTM C923/ASTM C923M.

F. Hydrostatic Test On Watertight Joints

1. Concrete, Clay, PVC and PE Pipe: A hydrostatic test shall be made on the watertight joint types as proposed. Only one sample joint of each type needs testing; however, if the sample joint fails because of faulty design or workmanship, an additional sample joint may be tested. During the test period, gaskets or other jointing material shall be protected from extreme temperatures which might adversely affect the performance of such materials. Performance requirements for joints in reinforced and nonreinforced concrete pipe shall conform to AASHTO M198 or ASTM C443M ASTM C443. Test requirements for joints in clay pipe shall conform to ASTM C425. Test requirements for joints in PVC and PE plastic pipe shall conform to ASTM D3212.

2. Corrugated Steel and Aluminum Pipe: A hydrostatic test shall be made on the watertight joint system or coupling band type proposed. The moment strength required of the joint is expressed as 15 percent of the calculated moment capacity of the pipe on a transverse section remote from the joint by the AASHTO HB-17 (Division II, Section 26). The pipe shall be supported for the hydrostatic test with the joint located at the point which develops 15 percent of the moment capacity of the pipe based on the allowable span in meters feet for the pipe flowing full or 40,000 foot-pounds (54,233 Newton meters), whichever is less. Performance requirements shall be met

at an internal hydrostatic pressure of 10 psi (69 kPa) for a 10 minute period for both annular corrugated metal pipe and helical corrugated metal pipe with factory reformed ends.

G. Erosion Control Riprap
1. Provide nonerodible rock not exceeding 15 inches (375 mm) in its greatest dimension and choked with sufficient small rocks to provide a dense mass with a minimum thickness of 8 inches (200 mm) or as indicated.

1.3 EXECUTION

A. Excavation for Pipe Culverts and Drainage Structures
1. Excavation of trenches, and for appurtenances and backfilling for culverts and storm drains, shall be in accordance with the applicable portions of Division 31 Section "Earth Moving" and the requirements specified below.
2. Trenching: The width of trenches at any point below the top of the pipe shall be not greater than the outside diameter of the pipe plus 12-inches (300 mm) each side of pipe to permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe. Sheeting and bracing, where required, shall be placed within the trench width as specified. Contractor shall not overexcavate. Where trench widths are exceeded, redesign with a resultant increase in cost of stronger pipe or special installation procedures will be necessary. Cost of this redesign and increased cost of pipe or installation shall be borne by the Contractor without additional cost to the Owner.
3. Removal of Rock: Rock in either ledge or boulder formation shall be replaced with suitable materials to provide a compacted earth cushion having a thickness between unremoved rock and the pipe of at least 8 inches (200 mm) or 1/2 inch (13 mm) for each meter foot of fill over the top of the pipe, whichever is greater, but not more than three-fourths the nominal diameter of the pipe. Where bell-and-spigot pipe is used, the cushion shall be maintained under the bell as well as under the straight portion of the pipe. Rock excavation shall be as specified and defined in Division 31 Section "Earth Moving".
4. Removal of Unstable Material: Where wet or otherwise unstable soil incapable of properly supporting the pipe, as determined by the the Owner, is unexpectedly encountered in the bottom of a trench, such material shall be removed to the depth required and replaced to the proper grade with select granular material, compacted as provided in paragraph BACKFILLING. When removal of unstable material is due to the fault or neglect of the Contractor while performing shoring and sheeting, water removal, or other specified requirements, such removal and replacement shall be performed at no additional cost to the Owner.

B. Bedding
1. The bedding surface for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe.
2. Concrete Pipe Requirements: When no bedding class is specified or detailed on the drawings, concrete pipe shall be bedded in a soil foundation accurately shaped and rounded to conform to the lowest one-fourth of the outside portion of circular pipe or to the lower curved portion of pipe arch for the entire length of the pipe or pipe arch. When necessary, the bedding shall be tamped. Bell holes and depressions for joints shall be not more than the length, depth, and width required for properly making the particular type of joint.
3. Clay Pipe Requirements: Bedding for clay pipe shall be as specified by ASTM C12.
4. Corrugated Metal Pipe: Bedding for corrugated metal pipe and pipe arch shall be in accordance with ASTM A798/A798M. It is not required to shape the bedding to the pipe geometry. However, for pipe arches, the Contractor shall either shape the bedding to the relatively flat bottom arc or fine grade the foundation to a shallow v-shape. Bedding for corrugated structural plate pipe shall meet requirements of ASTM A807/A807M.
5. Ductile Iron and Cast-Iron Pipe: Bedding for ductile iron and cast-iron pipe shall be as shown on the drawings.

6. Plastic Pipe: Bedding for PVC and PE pipe shall meet the requirements of ASTM D2321. Bedding, haunching, and initial backfill shall be either Class IB or II material.

C. Placing Pipe

1. Each pipe shall be thoroughly examined before being laid; defective or damaged pipe shall not be used. Plastic pipe shall be protected from exposure to direct sunlight prior to laying, if necessary to maintain adequate pipe stiffness and meet installation deflection requirements. Pipelines shall be laid to the grades and alignment indicated. Proper facilities shall be provided for lowering sections of pipe into trenches. Lifting lugs in vertically elongated metal pipe shall be placed in the same vertical plane as the major axis of the pipe. Pipe shall not be laid in water, and pipe shall not be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches during construction shall be provided as necessary. Deflection of installed flexible pipe shall not exceed the following limits:

TYPE OF PIPE	MAXIMUM ALLOWABLE DEFLECTION (%)
Corrugated Steel and Aluminum Alloy	5
Concrete-Lined Corrugated Steel	3
Ductile Iron Culvert	3
Plastic	7.5

Not less than 30 days after the completion of backfilling, the Owner may perform a deflection test on the entire length of installed flexible pipe using a mandrel or other suitable device. Installed flexible pipe showing deflections greater than those indicated above shall be retested by a run from the opposite direction. If the retest also fails, the suspect pipe shall be replaced.

2. Concrete, Clay, PVC, Ribbed PVC, Ductile Iron and Cast-Iron Pipe: Laying shall proceed upgrade with spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow.
3. Elliptical and Elliptical Reinforced Concrete Pipe: The manufacturer's reference lines, designating the top of the pipe, shall be within 5 degrees of a vertical plane through the longitudinal axis of the pipe, during placement. Damage to or misalignment of the pipe shall be prevented in all backfilling operations.
4. Corrugated PE Pipe: Laying shall be with the separate sections joined firmly on a bed shaped to line and grade and shall follow manufacturer's recommendations.
5. Corrugated Metal Pipe and Pipe Arch: Laying shall be with the separate sections joined firmly together, with the outside laps of circumferential joints pointing upstream, and with longitudinal laps on the sides. Part paved pipe shall be installed so that the centerline of bituminous pavement in the pipe, indicated by suitable markings on the top at each end of the pipe sections, coincides with the specified alignment of pipe. Fully paved steel pipe or pipe arch shall have a painted or otherwise applied label inside the pipe or pipe arch indicating sheet thickness of pipe or pipe arch. Any unprotected metal in the joints shall be coated with bituminous material as specified in AASHTO M190 or AASHTO M243. Interior coating shall be protected against damage from insertion or removal of struts or tie wires. Lifting lugs shall be used to facilitate moving pipe without damage to exterior or interior coatings. During transportation and installation, pipe or pipe arch and coupling bands shall be handled with care to preclude damage to the coating, paving or lining. Damaged coatings, pavings and linings shall be repaired in accordance with the manufacturer's recommendations prior to placing backfill. Pipe on which coating, paving or lining has been damaged to such an extent that satisfactory field repairs cannot be made shall be removed and replaced. Vertical elongation, where indicated, shall be accomplished by factory elongation. Suitable markings or properly placed lifting lugs shall be provided to ensure placement of factory elongated pipe in a vertical plane.
6. Structural-Plate Steel: Structural plate shall be installed in accordance with ASTM A807/A807M. Structural plate shall be assembled in accordance with instructions furnished by the manufacturer. Instructions shall show the position of each plate and the order of assembly. Bolts shall be tightened progressively and uniformly, starting at one end of the structure after all plates are in place. The operation shall be repeated to ensure that all bolts are tightened to meet the torque requirements of 200 foot-pounds (270 Newton meters) plus or minus 50 foot-pounds (68 Newton meters). Any power wrenches used shall be checked by the use of hand torque

wrenches or long-handled socket or structural wrenches for amount of torque produced. Power wrenches shall be checked and adjusted frequently as needed, according to type or condition, to ensure proper adjustment to supply the required torque.

7. Structural-Plate Aluminum: Structural plate shall be assembled in accordance with instructions furnished by the manufacturer. Instructions shall show the position of each plate and the order of assembly. Bolts shall be tightened progressively and uniformly, starting at one end of the structure after all plates are in place. The operation shall be repeated to ensure that all bolts are torqued to a minimum of 100 foot-pounds (136 Newton meters) on aluminum alloy bolts and a minimum of 150 foot-pounds (203 Newton meters) on galvanized steel bolts. Any power wrenches used shall be checked by the use of hand torque wrenches or long-handled socket or structural wrenches for the amount of torque produced. Power wrenches shall be checked and adjusted as frequently as needed, according to type or condition, to ensure that they are in proper adjustment to supply the required torque.
8. Multiple Culverts: Where multiple lines of pipe are installed, adjacent sides of pipe shall be at least half the nominal pipe diameter or 1 meter 3 feet apart, whichever is less.
9. Jacking Pipe Through Fills: Methods of operation and installation for jacking pipe through fills shall conform to requirements specified in Volume 1, Chapter 1, Part 4 of AREMA Manual.

D. Jointing

1. Concrete and Clay Pipe
   a. Cement-Mortar Bell-and-Spigot Joint: The first pipe shall be bedded to the established gradeline, with the bell end placed upstream. The interior surface of the bell shall be thoroughly cleaned with a wet brush and the lower portion of the bell filled with mortar as required to bring inner surfaces of abutting pipes flush and even. The spigot end of each subsequent pipe shall be cleaned with a wet brush and uniformly matched into a bell so that sections are closely fitted. After each section is laid, the remainder of the joint shall be filled with mortar, and a bead shall be formed around the outside of the joint with sufficient additional mortar. If mortar is not sufficiently stiff to prevent appreciable slump before setting, the outside of the joint shall be wrapped or bandaged with cheesecloth to hold mortar in place.
   b. Cement-Mortar Oakum Joint for Bell-and-Spigot Pipe: A closely twisted gasket shall be made of jute or oakum of the diameter required to support the spigot end of the pipe at the proper grade and to make the joint concentric. Joint packing shall be in one piece of sufficient length to pass around the pipe and lap at top. This gasket shall be thoroughly saturated with neat cement grout. The bell of the pipe shall be thoroughly cleaned with a wet brush, and the gasket shall be laid in the bell for the lower third of the circumference and covered with mortar. The spigot of the pipe shall be thoroughly cleaned with a wet brush, inserted in the bell, and carefully driven home. A small amount of mortar shall be inserted in the annular space for the upper two-thirds of the circumference. The gasket shall be lapped at the top of the pipe and driven home in the annular space with a caulking tool. The remainder of the annular space shall be filled completely with mortar and beveled at an angle of approximately 45 degrees with the outside of the bell. If mortar is not sufficiently stiff to prevent appreciable slump before setting, the outside of the joint thus made shall be wrapped with cheesecloth. Placing of this type of joint shall be kept at least five joints behind laying operations.
   c. Cement-Mortar Diaper Joint for Bell-and-Spigot Pipe: The pipe shall be centered so that the annular space is uniform. The annular space shall be caulked with jute or oakum. Before caulking, the inside of the bell and the outside of the spigot shall be cleaned.
      1) Diaper Bands: Diaper bands shall consist of heavy cloth fabric to hold grout in place at joints and shall be cut in lengths that extend one-eighth of the circumference of pipe above the spring line on one side of the pipe and up to the spring line on the other side of the pipe. Longitudinal edges of fabric bands shall be rolled and stitched around two pieces of wire. Width of fabric bands shall be such that after fabric has been securely stitched around both edges on wires, the wires will be uniformly spaced not less than 200 mm 8 inches apart. Wires shall be cut into

lengths to pass around pipe with sufficient extra length for the ends to be twisted at top of pipe to hold the band securely in place; bands shall be accurately centered around lower portion of joint.

2) Grout: Grout shall be poured between band and pipe from the high side of band only, until grout rises to the top of band at the spring line of pipe, or as nearly so as possible, on the opposite side of pipe, to ensure a thorough sealing of joint around the portion of pipe covered by the band. Silt, slush, water, or polluted mortar grout forced up on the lower side shall be forced out by pouring, and removed.

3) Remainder of Joint: The remaining unfilled upper portion of the joint shall be filled with mortar and a bead formed around the outside of this upper portion of the joint with a sufficient amount of additional mortar. The diaper shall be left in place. Placing of this type of joint shall be kept at least five joints behind actual laying of pipe. No backfilling around joints shall be done until joints have been fully inspected and approved.

d. Cement-Mortar Tongue-and-Groove Joint: The first pipe shall be bedded carefully to the established gradeline with the groove upstream. A shallow excavation shall be made underneath the pipe at the joint and filled with mortar to provide a bed for the pipe. The grooved end of the first pipe shall be thoroughly cleaned with a wet brush, and a layer of soft mortar applied to the lower half of the groove. The tongue of the second pipe shall be cleaned with a wet brush; while in horizontal position, a layer of soft mortar shall be applied to the upper half of the tongue. The tongue end of the second pipe shall be inserted in the grooved end of the first pipe until mortar is squeezed out on interior and exterior surfaces. Sufficient mortar shall be used to fill the joint completely and to form a bead on the outside.

e. Cement-Mortar Diaper Joint for Tongue-and-Groove Pipe: The joint shall be of the type described for cement-mortar tongue-and-groove joint in this paragraph, except that the shallow excavation directly beneath the joint shall not be filled with mortar until after a gauze or cheesecloth band dipped in cement mortar has been wrapped around the outside of the joint. The cement-mortar bead at the joint shall be at least 1/2 inch (15 mm), thick and the width of the diaper band shall be at least 8 inches (200 mm). The diaper shall be left in place. Placing of this type of joint shall be kept at least five joints behind the actual laying of the pipe. Backfilling around the joints shall not be done until the joints have been fully inspected and approved.

f. Plastic Sealing Compound Joints for Tongue-and-Grooved Pipe: Sealing compounds shall follow the recommendation of the particular manufacturer in regard to special installation requirements. Surfaces to receive lubricants, primers, or adhesives shall be dry and clean. Sealing compounds shall be affixed to the pipe not more than 3 hours prior to installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Sealing compounds shall be inspected before installation of the pipe, and any loose or improperly affixed sealing compound shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pulled together. If, while making the joint with mastic-type sealant, a slight protrusion of the material is not visible along the entire inner and outer circumference of the joint when the joint is pulled up, the pipe shall be removed and the joint remade. After the joint is made, all inner protrusions shall be cut off flush with the inner surface of the pipe. If nonmastic-type sealant material is used, the "Squeeze-Out" requirement above will be waived.

g. Flexible Watertight Joints: Gaskets and jointing materials shall be as recommended by the particular manufacturer in regard to use of lubricants, cements, adhesives, and other special installation requirements. Surfaces to receive lubricants, cements, or adhesives shall be clean and dry. Gaskets and jointing materials shall be affixed to the pipe not more than 24 hours prior to the installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Gaskets and jointing materials shall be inspected before installing the pipe; any loose or improperly affixed gaskets and jointing materials shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pushed home. If, while the joint is being made the gasket becomes visibly dislocated the pipe shall be removed and the joint remade.

h. External Sealing Band Joint for Noncircular Pipe: Surfaces to receive sealing bands shall be dry and clean. Bands shall be installed in accordance with manufacturer's recommendations.

2. Corrugated Metal Pipe

a. Field Joints: Transverse field joints shall be designed so that the successive connection of pipe sections will form a continuous line free of appreciable irregularities in the flow line. In addition, the joints shall meet the general performance requirements described in ASTM A798/A798M. Suitable transverse field joints which satisfy the requirements for one or more of the joint performance categories can be obtained with the following types of connecting bands furnished with suitable band-end fastening devices: corrugated bands, bands with projections, flat bands, and bands of special design that engage factory reformed ends of corrugated pipe. The space between the pipe and connecting bands shall be kept free from dirt and grit so that corrugations fit snugly. The connecting band, while being tightened, shall be tapped with a soft-head mallet of wood, rubber or plastic, to take up slack and ensure a tight joint. The annular space between abutting sections of part paved, and fully paved pipe and pipe arch, in sizes 30 inches (750 mm) or larger, shall be filled with a bituminous material after jointing. Field joints for each type of corrugated metal pipe shall maintain pipe alignment during construction and prevent infiltration of fill material during the life of the installations. The type, size, and sheet thickness of the band and the size of angles or lugs and bolts shall be as indicated or where not indicated, shall be as specified in the applicable standards or specifications for the pipe.

b. Flexible Watertight, Gasketed Joints: Installation shall be as recommended by the gasket manufacturer for use of lubricants and cements and other special installation requirements. The gasket shall be placed over one end of a section of pipe for half the width of the gasket. The other half shall be doubled over the end of the same pipe. When the adjoining section of pipe is in place, the doubled-over half of the gasket shall then be rolled over the adjoining section. Any unevenness in overlap shall be corrected so that the gasket covers the end of pipe sections equally. Connecting bands shall be centered over adjoining sections of pipe, and rods or bolts placed in position and nuts tightened. Band Tightening: The band shall be tightened evenly, even tension being kept on the rods or bolts, and the gasket; the gasket shall seat properly in the corrugations. Watertight joints shall remain uncovered for a period of time designated, and before being covered, tightness of the nuts shall be measured with a torque wrench. If the nut has tended to loosen its grip on the bolts or rods, the nut shall be retightened with a torque wrench and remain uncovered until a tight, permanent joint is assured.

E. Concrete Placement

1. Place cast-in-place concrete according to ACI 318/318R.

F. Drainage Structures

1. Manholes and Inlets: Construction shall be of reinforced concrete, plain concrete, brick, precast reinforced concrete, precast concrete segmental blocks, prefabricated corrugated metal, or bituminous coated corrugated metal; complete with frames and covers or gratings; and with fixed galvanized steel ladders where indicated. Pipe studs and junction chambers of prefabricated corrugated metal manholes shall be fully bituminous-coated and paved when the connecting branch lines are so treated. Pipe connections to concrete manholes and inlets shall be made with flexible, watertight connectors.
2. Walls and Headwalls: Construction shall be as indicated.

G. Steel Ladder Installation

1. Ladder shall be adequately anchored to the wall by means of steel inserts spaced not more than 6 feet (1.83 m) vertically, and shall be installed to provide at least 6 inches (152 mm) of space between the wall and the rungs. The wall along the line of the ladder shall be vertical for its entire length.

H. Backfilling

1. Backfilling Pipe in Trenches: After the pipe has been properly bedded, selected material from excavation or borrow, at a moisture content that will facilitate compaction, shall be placed along both sides of pipe in layers not exceeding 6 inches (150 mm) in compacted depth. The backfill shall be brought up evenly on both sides of pipe for the full length of pipe. The fill shall be thoroughly compacted under the haunches of the pipe. Each layer shall be thoroughly compacted with mechanical tampers or rammers. This method of filling and compacting shall continue until the fill has reached an elevation of at least 12 inches (300 mm) above the top of the pipe. The remainder of the trench shall be backfilled and compacted by spreading and rolling or compacted by mechanical rammers or tampers in layers not exceeding 8 inches (200 mm). Tests for density shall be made as necessary to ensure conformance to the compaction requirements specified below. Where it is necessary, in the opinion of the the Owner, that sheeting or portions of bracing used be left in place, the contract will be adjusted accordingly. Untreated sheeting shall not be left in place beneath structures or pavements.
2. Backfilling Pipe in Fill Sections: For pipe placed in fill sections, backfill material and the placement and compaction procedures shall be as specified below. The fill material shall be uniformly spread in layers longitudinally on both sides of the pipe, not exceeding 6 inches (150 mm) in compacted depth, and shall be compacted by rolling parallel with pipe or by mechanical tamping or ramming. Prior to commencing normal filling operations, the crown width of the fill at a height of 12 inches (300 mm) above the top of the pipe shall extend a distance of not less than twice the outside pipe diameter on each side of the pipe or 12 feet (4 m), whichever is less. After the backfill has reached at least 12 inches (300 mm) above the top of the pipe, the remainder of the fill shall be placed and thoroughly compacted in layers not exceeding 8 inches (200 mm).
3. Movement of Construction Machinery: When compacting by rolling or operating heavy equipment parallel with the pipe, displacement of or injury to the pipe shall be avoided. Movement of construction machinery over a culvert or storm drain at any stage of construction shall be at the Contractor's risk. Any damaged pipe shall be repaired or replaced.
4. Compaction
   a. General Requirements: Cohesionless materials include gravels, gravel-sand mixtures, sands, and gravelly sands. Cohesive materials include clayey and silty gravels, gravel-silt mixtures, clayey and silty sands, sand-clay mixtures, clays, silts, and very fine sands. When results of compaction tests for moisture-density relations are recorded on graphs, cohesionless soils will show straight lines or reverse-shaped moisture-density curves, and cohesive soils will show normal moisture-density curves.
   b. Minimum Density: Backfill over and around the pipe and backfill around and adjacent to drainage structures shall be compacted at the approved moisture content to the following applicable minimum density, which will be determined as specified below.
      1) Under airfield and heliport pavements, paved roads, streets, parking areas, and similar-use pavements including adjacent shoulder areas, the density shall be not less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material, up to the elevation where requirements for pavement subgrade materials and compaction shall control.
      2) Under unpaved or turfed traffic areas, density shall not be less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material.
      3) Under nontraffic areas, density shall be not less than that of the surrounding material.
5. Determination of Density: Testing shall be the responsibility of the Contractor and performed at no additional cost to the Owner. Testing shall be performed by an approved commercial testing laboratory or by the Contractor subject to approval. Tests shall be performed in sufficient number to ensure that specified density is being obtained. Laboratory tests for moisture-density relations shall be made in accordance with ASTM D1557 except that mechanical tampers may be used provided the results are correlated with those obtained with the specified hand tamper. Field density tests shall be determined in accordance with ASTM D2167 or ASTM D2922. When ASTM D2922 is used, the calibration curves shall be checked and adjusted, if necessary, using the sand cone method as described in paragraph Calibration of the referenced publications.

ASTM D2922 results in a wet unit weight of soil and when using this method ASTM D3017 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D3017 or ASTM D2922. Test results shall be furnished the the Owner. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed.

I. Pipeline Testing

1. Leakage Tests: Lines shall be tested for leakage by low pressure air or water testing or exfiltration tests, as appropriate. Low pressure air testing for vitrified clay pipes shall conform to ASTM C828. Low pressure air testing for concrete pipes shall conform to ASTM C924/ASTM C924M. Low pressure air testing for plastic pipe shall conform to ASTM F1417. Low pressure air testing procedures for other pipe materials shall use the pressures and testing times prescribed in ASTM C828 or ASTM C924/ASTM C924M, after consultation with the pipe manufacturer. Testing of individual joints for leakage by low pressure air or water shall conform to ASTM C1103/ASTM C1103M. Prior to exfiltration tests, the trench shall be backfilled up to at least the lower half of the pipe. If required, sufficient additional backfill shall be placed to prevent pipe movement during testing, leaving the joints uncovered to permit inspection. Visible leaks encountered shall be corrected regardless of leakage test results. When the water table is 600 mm 2 feet or more above the top of the pipe at the upper end of the pipeline section to be tested, infiltration shall be measured using a suitable weir or other device acceptable to the the Owner. An exfiltration test shall be made by filling the line to be tested with water so that a head of at least 2 feet (600 mm) is provided above both the water table and the top of the pipe at the upper end of the pipeline to be tested. The filled line shall be allowed to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, the head shall be reestablished. The amount of water required to maintain this water level during a 2-hour test period shall be measured. Leakage as measured by the exfiltration test shall not exceed 250 gallons per inch in diameter per mile (60 liters per mm in diameter per kilometer) of pipeline per day **OR** 0.2 gallons per inch in diameter per 100 feet (9 mL per mm in diameter per 100 meters), **as directed**, of pipeline per hour. When leakage exceeds the maximum amount specified, satisfactory correction shall be made and retesting accomplished.
2. Deflection Testing: Perform a deflection test on entire length of installed plastic pipeline on completion of work adjacent to and over the pipeline, including leakage tests, backfilling, placement of fill, grading, paving, concreting, and any other superimposed loads. Deflection of pipe in the installed pipeline under external loads shall not exceed 4.5 percent of the average inside diameter of pipe. Determine whether the allowable deflection has been exceeded by use of a pull-through device or a deflection measuring device.
    a. Pull-through device: This device shall be a spherical, spheroidal, or elliptical ball, a cylinder, or circular sections fused to a common shaft. Circular sections shall be so spaced on the shaft that distance from external faces of front and back sections will equal or exceed diameter of the circular section. Pull-through device may also be of a design promulgated by the Uni-Bell Plastic Pipe Association, provided that the device meets the applicable requirements specified in this paragraph, including those for diameter of the device. Ball, cylinder, or circular sections shall conform to the following:
        1) A diameter, or minor diameter as applicable, of 95 percent of the average inside diameter of the pipe; tolerance of plus 0.5 percent will be permitted.
        2) A homogeneous material throughout, with a density greater than 1.0 as related to water at 39.2 degrees F (4 degrees C), and a surface Brinell hardness of not less than 150.
        3) Center bored and through bolted with a 1/4 inch (6 mm) minimum diameter steel shaft having a yield strength of not less than 70,000 psi (483 MPa), with eyes or loops at each end for attaching pulling cables.
        4) Each eye or loop shall be suitably backed with a flange or heavy washer such that a pull exerted on opposite end of shaft will produce compression throughout remote end.

b. Deflection measuring device: Sensitive to 1.0 percent of the diameter of the pipe being tested and accurate to 1.0 percent of the indicated dimension. Deflection measuring device shall be approved by the the Owner prior to use.

c. Pull-through device: Pass the pull-through device through each run of pipe, either by pulling it through or flushing it through with water. If the device fails to pass freely through a pipe run, replace pipe which has the excessive deflection and completely retest in same manner and under same conditions as specified.

d. Deflection measuring device procedure: Measure deflections through each run of installed pipe. If deflection readings in excess of 4.5 percent of average inside diameter of pipe are obtained, retest pipe by a run from the opposite direction. If retest continues to show a deflection in excess of 4.5 percent of average inside diameter of pipe, remove pipe which has excessive deflection, replace with new pipe, and completely retest in same manner and under same conditions.

e. Warranty period test: Pipe found to have a deflection of greater than 5 percent of average inside diameter when deflection test is performed just prior to end of one-year warranty period shall be replaced with new pipe and tested as specified for leakage and deflection.

J. Field Painting

1. After installation, clean cast-iron frames, covers, gratings, and steps not buried in masonry or concrete to bare metal of mortar, rust, grease, dirt, and other deleterious materials and apply a coat of bituminous paint **OR** After installation, clean steel covers and steel or concrete frames not buried in masonry or concrete to bare metal of mortar, dirt, grease, and other deleterious materials. Apply a coat of primer and apply a top coat as specified in Division 09 Section "Exterior Painting", **as directed.** Do not paint surfaces subject to abrasion.

END OF SECTION 33 42 13 13

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Task	Specification	Specification Description
33 42 13 13	01 22 16 00	No Specification Required
33 42 13 13	21 05 23 00	Piped Utilities Basic Materials And Methods
33 42 13 13	22 05 76 00	Sanitary Sewerage
33 42 13 13	33 42 11 00	Storm Drainage
33 42 23 00	21 05 23 00	Piped Utilities Basic Materials And Methods
33 42 23 00	33 42 11 00	Storm Drainage
33 42 23 00	31 32 19 16	Sewage Treatment Lagoons
33 42 26 16	21 05 23 00	Piped Utilities Basic Materials And Methods
33 42 26 16	33 14 13 23	Sand Drains
33 42 26 16	33 42 11 00	Storm Drainage
33 42 26 19	21 05 23 00	Piped Utilities Basic Materials And Methods
33 42 26 19	33 42 11 00	Storm Drainage
33 42 26 23	33 42 11 00	Storm Drainage
33 42 31 00	21 05 23 00	Piped Utilities Basic Materials And Methods
33 42 31 00	33 42 11 00	Storm Drainage
33 42 31 00	31 32 19 16	Sewage Treatment Lagoons
33 42 33 00	21 05 23 00	Piped Utilities Basic Materials And Methods
33 42 33 00	33 42 11 00	Storm Drainage
33 42 33 00	31 32 19 16	Sewage Treatment Lagoons
33 42 36 00	21 05 23 00	Piped Utilities Basic Materials And Methods
33 42 36 00	33 42 11 00	Storm Drainage
33 42 36 00	31 32 19 16	Sewage Treatment Lagoons
33 44 36 00	22 13 19 26	Interceptors
33 44 36 00	28 46 00 00	Oil/Water Separator
33 46 53 00	21 05 23 00	Piped Utilities Basic Materials And Methods
33 46 53 00	33 14 13 23	Sand Drains
33 46 53 00	23 11 23 00	Relief Wells
33 52 16 13	01 22 16 00	No Specification Required
33 52 16 13	21 05 23 00	Piped Utilities Basic Materials And Methods
33 52 16 13	07 63 00 00	Common Work Results for Fire Suppression
33 52 16 13	07 63 00 00a	Common Work Results for Plumbing
33 52 16 13	07 63 00 00b	Common Work Results for HVAC
33 52 16 13	23 11 23 00b	Facility Natural-Gas Piping
33 52 16 13	23 11 23 00c	Facility Liquefied-Petroleum Gas Piping
33 52 16 23	23 11 23 00b	Facility Natural-Gas Piping
33 52 16 23	23 11 23 00c	Facility Liquefied-Petroleum Gas Piping
33 52 16 26	23 11 23 00b	Facility Natural-Gas Piping
33 52 16 26	23 11 23 00c	Facility Liquefied-Petroleum Gas Piping
33 53 16 00	21 05 23 00	Piped Utilities Basic Materials And Methods
33 59 11 00	21 05 23 00	Piped Utilities Basic Materials And Methods
33 59 16 00	21 05 23 00	Piped Utilities Basic Materials And Methods
33 61 13 00	21 05 23 00	Piped Utilities Basic Materials And Methods
33 61 13 00	33 14 13 23a	Hydronic Distribution

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SECTION 34 41 13 00 - ELECTRICAL TRAFFIC CONTROL SIGNALS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of electrical traffic control signals. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

1.2 PRODUCT

A. General: Replacement equipment items shall be regularly manufactured products.

B. Concrete Poles: Cement ASTM C 150; aggregate ASTM C 33; minimum compressive strength 6,000 psi when tested in compliance with AASHTO T22. Tensioning steel shall comply with ASTM A 603. Strands shall not be tensioned above 70 percent of the rated ultimate strength. Epoxy compound for sealing hollow cores shall comply with ASTM D 1763.

C. Galvanized Conduit Nipples: UL 514B.

D. Ground Wire: Cast-in-concrete pole, No. 6 stranded bare wire, ASTM A 603.

E. Wood Poles: ANSI 05.1, waterborne preservative-treated in compliance with AWPA C3, Retention Zone 1.

F. Structural Steel: ASTM A 36.

G. Steel Pipe: ASTM A 53.

H. Steel Bars: ASTM A 576.

I. Wire Strand: ASTM A 475.

J. Zinc Coatings: Members, ASTM A 123; fasteners, ASTM A 153.

K. Mast Arms for Supporting Traffic Signals: ASTM A 36; aluminum alloy 3003, or alloy alcad 3004 complying with ASTM B 209.

L. Concrete for Pull Boxes: ASTM C 94, 3,000 psi.

M. Cast-Iron Covers: ASTM A 48.

N. Signal Lens: Manufactured in compliance with Article 5 and 6, ITE Technical Report Number 1.

O. Loop Wire for Vehicle Detectors: No. 14 AWG or No. 12 AWG, stranded copper wire, type TTHN, THWN, or THW, ASTM B3.

P. Grout: One part cement complying with ASTM C 150 and two parts sand complying with ASTM C 33.

Q. Conduit: Polyvinyl chloride, UL 651, Schedule 40 or galvanized rigid metal, ASTM B 3.

R. Ground Wire: Soft drawn copper, bare, stranded, ANSI C7.1.

S. Electrical Work: NFPA No. 70.

1.3 EXECUTION

A. Scheduling and Coordination: The Contractor shall ensure that required notices have been given and that power interruptions have been scheduled and approved.

B. Traffic: Provide temporary traffic signs at and around work area. Signs and locations shall be as approved by the the Owner.

C. Vehicle Detector Assemblies, Loop Type: Saw out existing loops to be replaced to their full depth. Install and seal loop wire. Splice and solder loop wire and lead-in cable and wrap a minimum of two wraps with silicone tape and heavy-duty electrical tape. Install sealant in compliance with the manufacturer's recommendations. Excavate and remove existing lead-in cable to be replaced, and install new lead-in cable in place and connect to cabinet ground.

END OF SECTION 34 41 13 00

Task	Specification	Specification Description
34 41 13 00	01 22 16 00	No Specification Required
34 41 13 00	05 15 16 00	Ornamental Metal
34 41 13 00	27 11 19 00	Loose-Tube Gel-Filled Fiber Optic Cables
34 41 13 00	26 05 33 16a	Wiring Devices
34 41 16 00	34 41 13 00	Electrical Traffic Control Signals

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SECTION 34 71 13 13 - BEAM-TYPE GUARDRAIL

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for beam-type guardrail. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: For each type of product indicated.
2. Shop drawings shall be submitted for approval.

1.2 PRODUCTS

A. Rail Elements, End Sections, and Fasteners
1. ARTBA technical bulletin No. 268-B.
2. Provide galvanized steel W-beam in accordance with AASHTO M-180, class A, type 1.
3. Shop curve rail elements when required radius of installation on horizontal curve is 150 ft (46 m) or less. Provide W-beam rail (ARTBA RE-3) with a flared end section (ARTBA RE-5), rounded end section (ARTBA RE-6) at each end of installations.
4. Provide standard back-up plates behind rail elements at all intermediate, non-splice posts when steel posts and blocks are used.
5. Galvanize the rail sections, including end sections, in accordance with ASTM A 525, coating G-210.

B. Posts
1. Wood: Provide wood posts with blocks, size as required by State DOT. Rough sawn or S4S timber of Douglas Fir or any other locally approved species that is either No. 1 grade or Select Structural grade when graded in accordance with the requirements for Timber and Posts as set forth in WWPA-01 may be used. Give all wood posts and blocks a preservative treatment in accordance with the requirements of AASHTO M-133. Cut to length and bore posts and blocks for bolt holes before treatment.
2. Steel: Provide steel posts with blocks. Fabricate posts and blocks from W6X9 structural steel shapes complying with the requirements of ASTM A 36. Fabricate in the shop, grind smooth all corners and edges, galvanize posts and blocks after fabrication in accordance with ASTM A 123.

C. Bolts, Nuts, and Washers
1. Provide galvanized bolts, nuts, and washers that meet common ARTBA standards, designed to develop the required joint strength. Provide bolts with rounded heads to provide minimum obstruction.
2. Provide galvanized steel bolts conforming to the requirements of ASTM A 307, nuts conforming to the requirements of ASTM A 563, Grade A or better and galvanized steel washers, all galvanized in accordance with the requirements of ASTM A 153. Provide high strength bolts conforming to the requirements of ASTM A 325 where needed.

D. Reflectors: Provide guardrail reflectors as indicated. Place the galvanized steel tabs with reflective sheeting at every post except no reflectors are to be placed along the guardrail end flares.

E. Breakaway Cable Terminal (BCT) Assemblies: Provide BCT assemblies in accordance with the ARTBA details and standards referenced on the details.

F. Concrete and Reinforcement for the Post Footings: In accordance with applicable sections of Division 03 Section "Cast-in-place Concrete".

1.3 EXECUTION

A. Guardrail: Erect steel beam-type guardrail in locations and to lines and grades as directed and in accordance with details indicated.

B. Erection
1. Firmly set posts spaced at 6 ft. 3 in. (1.9 m) centers to the required depth. Set posts by placing in hand or mechanically dug holes or by driving, with or without pilot holes. Backfill gaps around posts with approved material that is moistened and thoroughly compacted. Repair damaged roadway surfacing where pavement is disturbed.
2. Position the top of W-beam rail at 27 in. (0.69 m) above the finished roadway surface. Align rail both vertically and horizontally within 1/4-in. (6 mm) from the theoretical alignments. Lap the rail sections at posts, in the direction of traffic in the adjacent lane, and lap end sections on the face of the rail.
3. Exercise care to avoid damage to treated wood and galvanized steel parts. Repair or replace damaged parts at the Contractor's expense. Securely tighten all bolts in the finished guardrail. Toenail the wood blocks to wood posts with two 16 penny galvanized nails, one on each side of the top of the block.

END OF SECTION 34 71 13 13

SECTION 34 71 13 16 - ACTIVE VEHICLE BARRIERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for active vehicle barriers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Shop Drawings: Installation, Equipment, and Electrical Work
a. Detail drawings containing complete wiring and schematic diagrams, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including foundation and clearances for maintenance and operation. For Federal work, detail drawings shall include a copy of the Department of State certificate of barrier performance.
2. Product Data:
a. Vehicle Barriers: A complete list of equipment, materials, including industrial standards used and how they apply to the applicable component and manufacturer's descriptive data and technical literature, catalog cuts, and installation instructions. Information necessary to document a minimum 1-year successful field operation performance history for each type of vehicle barrier installed.
b. Spare Parts: Spare parts data for each different item of material and equipment used, after approval of the detail drawings. The data shall include a complete list of parts and supplies, with current unit prices and source of supply.
3. Test Reports
a. Field Testing: Test reports in booklet form showing all field tests, including component adjustments and demonstration of compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall indicate the final position of controls.
4. Operation and Maintenance Data
a. Vehicle Barriers: Operating and Maintenance Instructions
1) Six copies of operation and maintenance manuals, a minimum of 2 weeks prior to field training. One complete set prior to performance testing and the remainder upon acceptance. Manuals shall be approved prior to acceptance. Operation manuals shall outline the step-by-step procedures required for system startup, operation, and shutdown. The manuals shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. Maintenance manuals shall include routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The manuals shall include piping layout, equipment layout, and simplified wiring and control diagrams of the system as installed. The manuals shall also include synthetic biodegradable hydraulic oil types to be used for ambient temperature ranges of minus 30 degrees F (minus 34 degrees C) to 150 degrees F (plus 66 degrees C) to cover winter operation, summer operation, and ambient temperature ranges in between.

C. General Requirements
1. Performance levels shall be based on the following:
a. The Department of State (DOS) publication SD-SDT-02.01 Specification for Vehicle Crash Testing of Perimeter Barriers and Gates (April 1985) in which:
1) Impact Conditions:

Condition Designation	Vehicle Weight	Impact Speed	Kinetic Energy
K4	15,000 lb (6,800 kg)	30 mph (48 km/h)	450,000 ft-lb (610 kJ)
K8	15,000 lb (6,800 kg)	40 mph (65 km/h)	800,000 ft-lb (1084 kJ)
K12	15,000 lb (6,800 kg)	50 mph (80 km/h)	1,250,000 ft-lb (1695 kJ)

2) Performance Levels:
   a) L 3.0 Vehicle and cargo are to be stopped although vehicle partial penetration and/or barrier deflection of up to 3 feet (1 m) permitted.
   b) L 2.0 Vehicle and cargo are to be stopped although vehicle partial penetration and/or barrier deflection of up to 20 feet (6 m) is permitted.
   c) L 1.0 Vehicle is disabled and does not travel more than 50 feet (15 m) after impact.

2. Vehicle Barriers furnished shall in all respects be identical to the unit tested and certified except for the width of the vehicle barrier, which is as indicated and except for bollards which have a diameter based on a required crash rating. Crash test shall be performed and data compiled by an approved independent testing agency. Test vehicle shall not vault or penetrate the barrier during the test. The design and structural materials of the vehicle barrier furnished shall be the same as those used in the crash tested barrier.

D. Nameplates
1. Nameplate data shall be permanently attached to each vehicle barrier. The data shall be legibly marked on corrosion-resistant metal plates and shall consist of at least the following:
   a. Manufacturer's name.
   b. Model number.
   c. Serial number.
   d. Date of manufacture.

E. Delivery And Storage
1. Components placed in storage shall be protected from the weather, humidity, and temperature variation, dirt and dust, or other contaminants. Structural materials shall be stored on sleepers or pallets and shall be protected from rust and objectionable materials such as dirt, grease, or oil.

F. Spare Parts
1. A manufacturer's standard recommended spare parts package, with current unit prices and source of supply complete with detailed manuals on parts replacement, shall be provided with each barrier to facilitate 1 year of normal operation. Particular consideration shall be given to system components which are not readily available from local or commercial sources and which are critical to the operation of the system.

G. Manufacturer's Services
1. Services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment supplied shall be available. The representative shall supervise the installation, adjustment, and testing of the equipment.

1.2 PRODUCT

A. Retractable Barriers: When in the raised position, the total retractable barrier heights shall be no less than 28 inches (711 mm) above the roadway surface and shall be 144 inches (3.66 m) wide. When in the lowered position, the retractable barrier shall extend no more than 5/8 inch (16 mm) above the roadway surface. Retractable barriers in the lowered position shall be capable of supporting a 32,000 pound (142 kN) axle load or a 16,000 (71 kN) wheel load. Design for this load shall be in accordance with AASHTO HB-17.
1. Powered Retractable Barrier: The retractable barrier shall be capable of 300 complete up/down cycles per hour. The retractable barrier motion shall be instantly reversible and shall be capable

of raising the barrier from the lowered position to the raised position within 8 seconds during normal use, and within 2 seconds during an emergency. Also, the barrier shall be capable of being lowered from the raised position to the lowered position in not more than 3 seconds. Retractable barrier shall withstand a K4 **OR** K8 **OR** K12, **as directed**, impact condition with Performance Level of L1.0 **OR** L2.0 **OR** L3.0, **as directed**.

a. Failure Modes of Operation: The system shall be designed to remain in the last commanded position in the event of hydraulic, electrical, or mechanical failure. A manual pump, or other system, shall be included for operation of hydraulic barriers without power.

b. Electric Motors: Unless otherwise indicated, electric motors shall have drip-proof **OR** totally enclosed **OR** totally enclosed fan cooled, **as directed**, enclosures. All couplings, motor shafts, gears, and other moving parts shall be fully guarded in accordance with 29 CFR 1910 Subpart O. Guards shall be removable without disassembling the guarded unit. For multiple barriers operated from a single hydraulic unit it is highly recommended that the electric motor be 3-phase.

c. System: The system shall be designed to maintain the barriers in the raised position, without inspection, for periods of time of up to 1 week. If a hydraulic system is used, it shall be equipped with pressure relief valves to prevent overpressure. The system shall not require continuous running of the motor to stay in the raised position, excluding the use of manual pinning to do so.

d. Hydraulic Power Unit: The hydraulic power unit shall contain synthetic biodegradable hydraulic fluid which maintains its viscosity operating range, even at constant heaviest use rate, for an ambient temperature range of 20 to 150 degrees F (minus 7 to plus 66 degrees C). A hydraulic fluid heater shall be provided so that the viscosity remains within its operating range if ambient temperatures below 20 degrees F (minus 7 degrees C) are expected. Buried hydraulic lines for the connection of the hydraulic power unit to the barrier shall be flexible or carbon steel pipe, or a combination of flexible and carbon steel pipe. Flexible and rigid hydraulic line working pressures shall exceed the maximum system relief pressure. PVC pipe and fittings for burial of hydraulic lines shall be in accordance with ASTM D 3034 Type PS 46 with minimum pipe stiffness of 46.
   1) Flexible hydraulic lines shall be in accordance with SAE J517.
   2) Rigid hydraulic lines shall be seamless carbon steel pipe in accordance with ASTM A 106.

e. Hydraulic Power Unit Enclosure: A NEMA Type 3R enclosure as specified in NEMA 250 shall be provided to enclose the hydraulic power unit. The enclosure shall be designed for easy removal of the hydraulic power unit and other accessories without complete removal of the enclosure. An access door with hinges and an inside and outside operable/lockable (exterior) door latch shall be provided. Equipment within the enclosure shall be placed and configured so that all periodic maintenance can be performed through the access door without removal of the equipment. The enclosure shall be equipped with weatherproof louver vents appropriately sized and located to dissipate internal heat generation.

2. Manual Retractable Barriers: The manual barrier shall be capable of being raised and lowered by manual means such as levers or hydraulics requiring a maximum 60 pounds (267 N) of force. The manual mechanism shall contain a locking pin which accepts a padlock for securing the barrier when it is in the "UP" position. Retractable barrier shall withstand a K4 **OR** K8 **OR** K12, **as directed**, impact condition with Performance Level of L1.0 **OR** L2.0 **OR** L3.0, **as directed**. Barrier should be capable of being locked in the down position.

B. Retractable Bollards: The total bollard height when in the raised position shall be no less than 30 inches (750 mm) above the roadway surface and shall have an outside diameter of no less than 8 inches (200 mm). A bollard system shall consist of a minimum of 3 bollards spaced no more than 36 inches (915 mm) from centerline to centerline of bollards across a 10 foot (3.0 m) roadway. Bollards in the lowered position shall be capable of supporting a 16,000 pound (71 kN) wheel load each. Design for this load shall be in accordance with AASHTO HB-17. Retractable bollards shall withstand a K4 **OR** K8 **OR** K12, **as directed**, Impact Condition with Performance Level of L1.0 **OR** L2.0 **OR** L3.0, **as directed**.

1. Powered Retractable Bollards: The retractable bollard shall be capable of 300 complete up/down cycles per hour. Bollards shall be capable of being raised or lowered within a 3 to 15-second range during normal use and within 2.5 seconds for emergency operations.
   a. Failure Modes of Operation: The system shall be designed to prevent lowering of the barrier in the event of hydraulic, electrical, or mechanical failure. A manual pump, or other system, shall be included for operation of hydraulic and/or mechanical barriers without power.
   b. Electric Motors: Unless otherwise indicated, electric motors shall have drip-proof **OR** totally enclosed, **as directed**, enclosures. For multiple barriers being operated from a hydraulic power unit it is highly recommended that the electric motor be 3-phase.
   c. System: The system shall be designed to maintain the barriers in the raised position, without inspection, for period of time of up to 1 week. If a hydraulic system is used, it shall be equipped with pressure relief valves to prevent overpressure.
   d. Hydraulic Power Unit: The hydraulic power unit shall contain synthetic biodegradable hydraulic fluid which maintains its viscosity operating range, even at constant heaviest use rate, for an ambient temperature range of 20 to 150 degrees F (minus 7 to plus 66 degrees C). A hydraulic fluid heater shall be provided so that the viscosity remains within its operating range, if ambient temperatures below 20 degrees F (minus 7 degrees C) are expected. Buried hydraulic lines for the connection of the hydraulic power unit to the barrier shall be flexible or carbon steel pipe, or a combination of flexible and carbon steel pipe. Flexible and rigid hydraulic line working pressures shall exceed the maximum system relief pressure. PVC pipe and fittings for burial of hydraulic lines shall be in accordance with ASTM D 3034 Type PS 46 with minimum pipe stiffness of 46.
      1) Flexible hydraulic lines shall be in accordance with SAE J517.
      2) Rigid hydraulic lines shall be seamless carbon steel pipe in accordance with ASTM A 106.
   e. Hydraulic Power Unit Enclosure: A NEMA Type 3R enclosure as specified in NEMA 250 shall be provided to enclose the hydraulic power unit. The enclosure shall be designed for easy removal of the hydraulic power unit and other accessories without complete removal of the enclosure. An access door with hinges and an inside and outside operable/lockable (exterior) door latch shall be provided. Equipment within the enclosure shall be placed and configured so that all periodic maintenance can be performed through the access door without removal of the equipment. The enclosure shall be equipped with weatherproof louver vents appropriately sized and located to dissipate internal heat generation.
2. Manual Retractable Bollards: Manual bollards shall be capable of being raised and lowered utilizing a recessed handle on the top surface of the bollard or a manual hydraulic pump, either requiring a maximum 60 pounds (267 N) of force. A mechanism, that is lockable, shall be provided to secure the bollard in either the full "UP" or full "DOWN" position.

C. Crash Gate: The crash gate shall consist of steel buttresses anchored into the ground and an above grade assembly consisting of a heavy steel structure or a combination of heavy steel and structural aluminum capable of being opened and closed. The height of the gate shall be a minimum of 84 inches (2.1 m) from the road surface to the top of the gate frame. The length shall close and protect a minimum 120 inch (3.0 m) clear opening. The maximum clear opening between the gate frame and end posts, between the bottom of the gate and finished grade, and between any grill work shall be 3 inches (75 mm).
   1. Powered Crash Gate: The gate movement shall be controlled by an electro-mechanical gate operator **OR** a hydraulic gate operator, **as directed**, consisting of an operator unit with required control circuits and operator station. The control and operating voltage shall be 24 vac (nominal) or, as an option 24 vdc. A remote control master station shall be capable of driving the gate at minimum 48 fpm (14.6 m per minute) for a slide gate or 6 degrees per second for a swing gate. Unless otherwise indicated, motors shall have drip-proof **OR** totally enclosed, **as directed**, enclosures. Crash gate shall withstand a 15,000 pound (6804 kg) vehicle at impact speed of 30 **OR** 40 **OR** 50, **as directed**, mph (48 **OR** 64 **OR** 80, **as directed**, km/hour), with maximum barrier deflection or vehicle penetration of 3 feet (1 m).

a. Failure Mode of Operation: The system shall be designed to prevent opening of the crash gate in the event of electrical or mechanical failure. A disconnect system for the gate drive shall be provided to allow manual operation of the barrier in the event of a power outage.

b. Hydraulic Power Unit: The hydraulic power unit shall contain synthetic biodegradable hydraulic fluid which maintains its viscosity within its operating range, even at constant heaviest use rate, for an ambient temperature range of 20 to 150 degrees F (minus 7 to plus 66 degrees C). A hydraulic fluid heater shall be provided so that the viscosity remains within its operating range if ambient temperatures below 20 degrees F (minus 7 degrees C) are expected. Buried hydraulic lines for the connection of the hydraulic power unit to the barrier shall be flexible or carbon steel pipe, or a combination of flexible and carbon steel. Flexible and rigid hydraulic line working pressures shall exceed the maximum system relief pressure. PVC pipe and fittings for burial of hydraulic lines shall be in accordance with ASTM D 3034 Type PS 46 with minimum pipe stiffness of 46.
   1) Flexible hydraulic lines shall be in accordance with SAE J517.
   2) Rigid hydraulic lines shall be seamless carbon steel pipe in accordance with ASTM A 106.

c. Hydraulic Power Unit Enclosure: A NEMA Type 3R enclosure as specified in NEMA 250 shall be provided to enclose the hydraulic power unit. The enclosure shall be designed for easy removal of the hydraulic power unit and other accessories without complete removal of the enclosure. An access door with hinges and an inside and outside operable/lockable (exterior) door latch shall be provided. Equipment within the enclosure shall be placed and configured so that all periodic maintenance can be performed through the access door without removal of the equipment. The enclosure shall be equipped with weatherproof louver vents appropriately sized and located to dissipate internal heat generation.

2. Manual Crash Gate: The manual crash gate shall be capable of being hinged from either side. Hinge points of both buttresses shall each contain a locking pin with padlock acceptance for securing the crash gate in the closed position. The crash gate shall withstand a 10,000 pound (4535 kg) vehicle at impact speed of 50 mph (80 km/hour), with maximum gate deflection or vehicle penetration of 10 feet (3 m) 15,000 pound (6804 kg) vehicle traveling at impact speed of 30 **OR** 40 **OR** 50, **as directed**, mph (48 **OR** 64 **OR** 80, **as directed**, km/hour), with a maximum gate deflection or vehicle penetration of up to 3 feet (1 m).

D. Crash Beam: The crash beam shall be an above-grade assembly that, in the "DOWN" position, shall present a visible obstacle to approaching vehicles. The height of the barrier shall be a minimum of 30 inches (750 mm) as measured from the roadway surface to the centerline of the crash beam. The crash beam shall be capable of blocking a minimum road width of 120 inches (3.0 m). The crash beam end shall contain a locking pin with padlock acceptance for securing the crash beam when it is in the "DOWN" position. Crash beam shall withstand a 15,000 pound (6804 kg) vehicle traveling at 30 **OR** 40 **OR** 50, **as directed**, mph (48 **OR** 64 **OR** 80, **as directed**, km/hour), with maximum vehicle penetration of 20 feet (6 m) 10,000 pound (4535 kg) vehicle at impact speed of 15 mph (24 km/hour), with a maximum vehicle penetration of 10 feet (3 m).

1. Powered Crash Beam: The crash beam shall be operated by means of a hydraulic power system. The crash beam shall be capable of being raised or lowered within an 8 to 15 second time range.

a. Failure Mode of Operation: A disconnect system for the crash beam shall be provided to allow manual operation of the barrier in the event of an electrical or mechanical failure.

b. Hydraulic Power Unit: The hydraulic power unit shall contain synthetic biodegradable hydraulic fluid which maintains its viscosity operating range, even at constant heaviest use rate, for an ambient temperature range of 20 to 150 degrees F (minus 7 to plus 66 degrees C). A hydraulic fluid heater shall be provided so that the viscosity remains within its operating range if ambient temperatures below 20 degrees F (minus 7 degrees C) are expected. Buried hydraulic lines for the connection of the hydraulic power unit to the barrier shall be flexible or carbon steel pipe or a combination of flexible and carbon steel pipe. Flexible and rigid hydraulic line working pressures shall exceed the maximum system relief pressure. PVC pipe and fittings for burial of hydraulic lines shall be in accordance with ASTM D 3034 Type PS 46 with minimum pipe stiffness of 46.

1) Flexible hydraulic lines shall be in accordance with SAE J517.
2) Rigid hydraulic lines shall be seamless carbon steel pipe in accordance with ASTM A 106.

c. Hydraulic Power Unit Enclosure: A NEMA Type 3R enclosure as specified in NEMA 250 shall be provided to enclose the hydraulic power unit. The enclosure shall be designed for easy removal of the hydraulic power unit components and other accessories without complete removal of the enclosure. An access door with hinges and an inside and outside operable/lockable exterior door latch shall be provided. Equipment within the enclosure shall be placed and configured so that all periodic maintenance can be performed through the access door without removal of the equipment. The enclosure shall be equipped with weatherproof louver vents appropriately sized and located to dissipate internal heat generation.

2. Manual Crash Beam: The crash beam shall be manually raised and lowered with the aid of a counterbalanced end requiring approximately 60 pounds (267 N) of force.

E. Portable Retractable Barrier: The portable retractable barrier shall be transportable and capable of manual and/or electro-mechanical operation. When in the raised position, the total barrier heights shall be no less than 28 inches (711 mm) above the roadway surface and shall be up to 144 inches (3.66 m wide). The barrier shall be equipped with entrance/exit ramps when the barrier extends more than 5/8 inch (16 mm) above the roadway surface. Retractable barriers in the lowered position shall be capable of supporting a 32,000 pound (142 kN) axle load or a 16,000 (71 kN) pound wheel load. Design for this load shall be accordance with AASHTO HB-17.

1. Powered Portable Retractable Barrier: The portable retractable barrier shall be capable of 300 complete up/down cycles per hour. The retractable barrier motion shall be instantly reversible and shall be capable of raising the barrier from the lowered position to the raised position within 8 seconds during normal use, and within 2 seconds during an emergency. Also, the barrier shall be capable of being closed from the raised position to the lowered position in not more than 3 seconds. Retractable barrier shall withstand a K4 **OR** K8 **OR** K12, **as directed**, impact condition with Performance Level of L1.0 **OR** L2.0 **OR** L3.0, **as directed**. Portable retractable barrier, when impacted by a 15,000 pound (6,800 kg) vehicle at impact speed of 50 mph (80 km/hour) shall disable the vehicle and allow it to travel no more than 50 feet (15.2 m) after impact. Portable power assisted retractable barriers shall be equipped with on and off ramps for smooth transition between surfaces when the barrier extends more than 5/8 inch (16 mm) above the roadway surface.
   a. Failure Modes of Operation: The system shall be designed to prevent lowering of the barrier in the event of hydraulic, electric, or mechanical failure. A manual pump shall be included for operation of hydraulic and/or mechanical barriers without power.
   b. Electric Motors: Unless otherwise indicated, electric motors shall have drip-proof **OR** totally enclosed, **as directed**, enclosures.
   c. System: The system shall be designed to maintain the barriers in the raised position, without inspection, for periods of time of up to 1 week. If a hydraulic system is used, it shall be equipped with pressure relief valves to prevent overpressure.
   d. Hydraulic Power Unit: The hydraulic power unit shall contain synthetic biodegradable hydraulic fluid which maintains its viscosity operating range, even at constant heaviest use rate, for an ambient temperature range of 20 to 150 degrees F (minus 7 to plus 66 degrees C). A hydraulic fluid heater shall be provided so that the viscosity remains within its operating range if ambient temperatures below 20 degrees F (minus 7 degrees C) are expected. Flexible hydraulic lines shall be used for the connection of the hydraulic power unit to the barrier. Flexible hydraulic line working pressures shall exceed the maximum system relief pressure; flexible hydraulic lines shall be in accordance with SAE J517.
2. Manual Retractable Portable Barriers: The manual barrier shall be capable of being raised and lowered by manual means such as levers or hydraulics requiring a maximum 60 pounds (267 N) of force. The manual mechanism shall contain a locking pin which accepts a padlock for securing the barrier when it is in the "UP" position and shall also be capable of being locked in the

"DOWN" position. Retractable barrier shall withstand a K4 **OR** K8 **OR** K12, **as directed**, impact condition with Performance Level of L1.0 **OR** L2.0 **OR** L3.0, **as directed**

F. Portable Crash Beam: The portable crash beam shall be an above-grade assembly that, in the "DOWN" position, shall present a visible obstacle to approaching vehicles. The height of the barrier shall be a minimum of 30 inches (750 mm) as measured from the roadway surface to the centerline of the crash beam. The crash beam shall be capable of blocking a minimum road width of 120 inches (3.0 m). The crash beam end shall contain a locking pin with padlock acceptance for securing the crash beam when it is in the "DOWN" position. Crash beam shall withstand a 15,000 pound (6804 kg) vehicle traveling at 30 mph (48 km/hour), with maximum vehicle penetration and/or barrier deflection of 20 feet (6 m).

1. Powered Portable Crash Beam: The portable crash beam shall be operated by means of a hydraulic power system. The crash beam shall be capable of being raised or lowered within an 8 to 15 second time range.
   a. Failure Mode of Operation: A disconnect system for the portable crash beam shall be provided to allow manual operation of the barrier in the event of an electrical or mechanical failure.
   b. Hydraulic Power Unit: The hydraulic power unit shall contain synthetic biodegradable hydraulic fluid which maintains its viscosity operating range, even at constant heaviest use rate, for an ambient temperature range of 20 to 150 degrees F (minus 7 to plus 66 degrees C). A hydraulic fluid heater shall be provided so that the viscosity remains within its operating range if ambient temperatures below 20 degrees F (minus 7 degrees C) are expected. Flexible hydraulic lines shall be used for the connection of the hydraulic power unit to the barrier. Flexible hydraulic line working pressures shall exceed the maximum system relief pressure; flexible hydraulic lines shall be in accordance with SAE J517.
   c. Hydraulic Power Unit Enclosure: A weather resistant enclosure shall be provided to enclose the hydraulic power unit. The enclosure shall be designed for easy removal of the hydraulic power unit components and other accessories without complete removal of the enclosure. An access door with hinges and an inside and outside operable lockable (exterior) door latch shall be provided. Equipment within the enclosure shall be placed and configured so that all periodic maintenance can be performed through the access door without removal of the equipment. The enclosure shall be equipped with weatherproof louver vents appropriately sized and located to dissipate internal heat generation.
2. Manual Portable Crash Beam: The crash beam shall be manually operated by means of a counter balanced system requiring approximately 60 pounds (267 N) of force.

G. Electrical Work: Motors, manual or automatic motor control equipment except where installed in motor control centers and protective or signal devices required for the operation specified herein shall be provided in accordance with Division 22. All field wiring for loop detectors, communication lines, and power circuits shall have surge protection. Any wiring required for the operation specified herein, but not shown on the electrical plans, shall be provided under this section in accordance with Division 22.

H. Control Panel: A control panel and control circuit shall be provided to interface between all barrier control stations and the power unit. A control panel shall be provided for the inbound lanes and a separate one for the outbound lanes where the barriers are located. The control station is defined as the main control panel and the remote control panel as shown. The control circuit shall contain all relays, timers, and other devices or an industrial programmable controller programmed as necessary for the barrier operation. The control panel shall allow direct interface with auxiliary equipment such as card readers, remote switches, loop detectors, infrared sensors, and sliding **OR** swinging, **as directed**, gate limit switches. Loop controllers shall not cause an automatic barrier raise following power loss or restoration. The enclosure shall be as indicated on the drawings. All device interconnect lines shall be run to terminal strips.

1. Voltage: The control circuit shall operate from a 120 volt 60 **OR** 50, **as directed**, Hz supply. The control circuit voltage shall be 12 **OR** 24, **as directed**, ac **OR** dc, **as directed**, for all external control panels.

2. Main Control Panel: A main control panel shall be supplied to control barrier function. This panel shall have a key-lockable main switch with main power "ON" and panel "ON" lights. Buttons to raise and lower each barrier **OR** set of barriers, **as directed**, shall be provided. Barrier "UP" and "DOWN" indicator lights shall be included for each barrier **OR** set of barriers, **as directed**. An emergency fast operate circuit (EFO) shall be operated from a push button larger than the normal controls and have a flip safety cover installed over the push button or toggle switch. The EFO shall also be furnished with an EFO-active light and reset button. The main control panel shall have a key lockable switch to arm or disable the remote control panel. An indicator light shall show if the remote control panel is enabled.
3. Remote Control Panel: A remote control panel, one panel for the inbound lane(s) and a separate panel for the outbound lane(s), shall have a panel "ON" light that is lit when enabled by a key lockable switch on the main control panel. Buttons to raise and lower each barrier shall be provided. Barrier "UP" and "DOWN" indicator lights shall be included for each barrier. The EFO shall be operated from a push button larger than the normal controls and have a flip safety cover installed over the push button or toggle switch. Activation of either EFO will operate all barriers. The EFO shall be interconnected with an EFO-active light. When the remote control panel EFO is pushed, operation of the barrier will not be possible from this panel until reset at the main control panel.

I. Miscellaneous Equipment
1. Safety Equipment
   a. Barrier Systems Sensors: The sensors shall be compatible with the barrier controller and shall function as part of a complete barrier control system. The barrier system sensors shall consist of the following:
      1) Suppression Loops - Two inductive loops whose outputs shall be used to prevent barriers raising when a vehicle is within a prescribed distance of the barrier. The output of the loops shall override all barrier rise signals until one second after a vehicle clears the suppression loop.
      2) Speed Loops - Two inductive loops whose output shall be used to signal the barrier controller of a vehicle approaching at a speed greater than the posted speed (25 mph (11.2 m/sec) or less (recommended)). The speed loops shall cause the barrier control panel to annunciate a warning sound alerting the guard to make a decision as to whether the barrier should be raised or not.
      3) Wrong Way Loops - Two inductive loops whose output shall be used to signal the barrier control panel to ennunciate a warning sound if a vehicle is attempting to enter the facility through the exit lane. The warning sound will alert the guard to make a decision as to whether the barrier should be raised or not.
   b. Traffic Lights: Red/yellow 8 inch (200 mm) traffic lights shall be supplied for each entrance and exit to alert motorists of the barrier position. Traffic lights are not required for manual barriers. The yellow flashing light shall indicate that the barrier is fully open. All other positions shall cause the light to show red. Brackets shall be supplied to allow the light to be mounted a minimum 4.5 feet (1.4 m) above the roadway pavement on a 3.5 inch (90 mm) outside diameter metal post or mounted directly on the crash gate.
2. Warning Annunciator: Provide a warning annunciator built into the barrier control panel that produces a pulsing audible sound when the speed loop detects a vehicle entering the facility with excess speed. Provide a warning annunciator built into the barrier control panel that produces a continuous sound whenever a wrong way loop detects a vehicle entering from the exit. The warning annunciator shall sound until a warning annunciator silence reset button is pressed.
3. Heater: A waterproof barrier heater with a thermostat control and NEMA 4 junction box connection point shall be provided for de-icing and snow melting. The heater shall provide barrier operation to an ambient temperature of minus 40 degrees F (minus 40 degrees C). For retractable bollards, a 250-watt heater shall be provided for each bollard.
4. Signage: Signage shall read "Axle Weight Limit 9 Tons" and shall conform to FHWA SA-89-006 sign (R12.2).

5. Vertical Arm Gates (Traffic Arms): Vertical arm gates shall have an opening and closing time of less than or equal to 5 seconds. The gates shall be capable of 500 duty cycles per hour as a minimum. Gate shall operate the arm through 90 degrees. Gate operators shall be supplied with single phase 120 volt motors. Each entry lane shall be provided with a vertical arm gate. Each gate shall be capable of being operated from a remote open-close push button station in each guard booth and the gatehouse for the respective entry lane. Gates shall have a hand-crank, or other means, which will allow manual operation during power failures. Gate arms shall be constructed out of wood, steel, fiberglass, or aluminum, as specified by the manufacturer for the given lengths as shown on the drawings. Gate arms shall be covered with 16 inch (406 mm) wide reflectorized red and white sheeting. Each gate shall be furnished with a spare gate arm. Gate operator cabinets shall be constructed of galvanized steel, or aluminum and shall be painted manufacturers standard color as approved. Each gate operator shall be provided with an obstruction detector that will automatically reverse the gate motor when an obstruction is detected. The obstruction detector shall be any of the following 3 types: An electronic loop vehicle detector buried in the road, a photocell electric eye mounted on the gate operator, or a safety strip mounted on the lower edge of the arm. The detector system shall be automatically deactivated when the arm reaches the fully lowered position. Slab size and anchorage for gate operator shall be per manufacturer requirements.
6. Vehicle Barrier Vertical Arm Gate (Traffic Arm): A traffic arm, as a separate piece of equipment, will be included with each non-portable active vehicle barrier as part of the barrier safety operating system. This traffic arm shall automatically deploy (close) when the emergency up button is activated and open when the vehicle barrier is reset. This traffic arm will not be equipped with an automatic obstruction detector.

J. Finish: Surfaces shall be painted in accordance with requirements of Division 09 Section(s) "Exterior Painting" OR "Interior Painting", as applicable. The roadway plate shall have a nonskid surface painted white with reflective red 4 **OR** 6, **as directed**, inch (100 **OR** 150, **as directed**, mm) wide red reflective stripes 4 inches (100 mm) apart. The barrier front shall be painted white and have 4 **OR** 6, **as directed**, inch (100 **OR** 150, **as directed**, mm) wide reflective red stripes 4 inches (100 mm) apart. The diagonal striping should point down and outward from the center of the device. Bollards shall be painted white with 2 **OR** 3, **as directed**, inch (50 **OR** 75, **as directed**, mm) wide reflective red diagonal stripes. The barrier crash gate shall be painted as specified by purchaser and the crash beam shall be painted white with 3 inch (75 mm) wide reflective red diagonal stripes.

K. Concrete: The concrete shall conform to Division 03 Section "Cast-in-place Concrete".

L. Welding: Welding shall be in accordance with AWS D1.1/D1.1M.

M. Pavement: After placement of the vehicle barrier, the pavement sections shall be replaced to match the section and depth of the surrounding pavement. Pavement shall be warped to match the elevations of existing pavement. Positive surface drainage, away from the vehicle barrier, shall be provided by pavement slope.

1.3 EXECUTION

A. Installation: Installation shall be in accordance with manufacturer's instructions and in the presence of a representative of the manufacturer. Manufacturer's representative shall be experienced in the installation, adjustment, and operation of the equipment provided. The representative shall also be present during adjustment and testing of the equipment.

B. Hydraulic Lines: Buried hydraulic lines shall be placed in polyvinyl chloride (PVC) sleeves. Positive drainage shall be provided from the hydraulic power unit to the barrier for drainage of condensation within the PVC sleeve.

C. Pit Drainage: A drain connection and oil/water separator, **as directed**, shall be provided in each barrier that requires pit/vault type construction. Hookups between the storm drains shall be made. The self-priming sump pump shall have the capacity to remove minimum 150 gallons per minute (34 cubic meters per hour).

D. Electrical: All control power wiring requiring compression terminals shall use ring-style terminals. Terminals and compression tools shall conform to UL 486A. Roundhead screws and lockwashers shall be used to provide vibration-resistant connections. Connections between any printed circuit cards and the chassis shall be made with screw connections or other locking means to prevent shock or vibration separation of the card from its chassis. The electrical power supply breaker for the hydraulic power unit shall be capable of being locked in the power on and power off positions.

E. Field Testing: Upon completion of construction, a field test shall be performed for each vehicle barrier. The test shall include raising and lowering the barrier, both electrically and manually, through its complete range of operation. Each vehicle barrier shall then be continuously cycled for not less than 30 minutes to test for heat build-up in the hydraulic system. the Owner shall be notified at least 7 days prior to the beginning of the field test. The Contractor shall furnish all equipment and make all necessary corrections and adjustments prior to tests witnessed by the Owner. Any conditions that interfere with the proper operation of the barrier disclosed by the test shall be corrected at no additional cost to the Owner. Adjustments and repairs shall be done by the Contractor under the direction of the Owner. After adjustments are made to assure correct functioning of components, applicable tests shall be completed.

F. Field Training: A field training course shall be provided for designated operating staff members. Training shall be provided for a total period of not less than 8 hours (for electrical/hydraulic operated units) or 1 hour (for manually operated units) of normal working time and shall start after the system is functionally complete but prior to final acceptance tests. Field training shall cover all of the items contained in the operating and maintenance instructions.

END OF SECTION 34 71 13 16

Task	Specification	Specification Description
34 71 13 16	34 71 13 13	Beam-Type Guardrail
34 71 13 26	01 22 16 00	No Specification Required
34 71 13 26	34 71 13 13	Beam-Type Guardrail
34 71 16 00	01 22 16 00	No Specification Required
34 71 16 00	34 71 13 16	Active Vehicle Barriers
34 71 16 00	34 71 13 13	Beam-Type Guardrail
34 71 19 16	11 12 16 00	Parking Control Equipment
34 71 19 16	11 12 16 00a	Prefabricated Control Booths

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Task	Specification	Specification Description
35 05 70 00	01 22 16 00	No Specification Required

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SECTION 35 24 23 00 - DREDGING

1.1 GENERAL

A. Description Of Work
1. This specification covers dredging. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Definition
1. Hard material is defined as material requiring blasting or the use of special equipment for economical removal, and includes boulders or fragments too large to be removed in one piece by the dredge.

C. Submittals: Submit the following:
1. Shop Drawings: Indicate pipeline location and installation details. Submit drawings of surveys during progress of work by soundings or sweepings.
2. Protection plan: If blasting will be allowed, submit a plan for protection of surrounding structures, equipment, and vessels.

D. Material to be Removed
1. The material to be removed is silt and mud **OR** new material, **as directed**, applicable to the specific project.
a. Hard Material: Remove hard material. Blasting will not be permitted **OR** Blasting shall be performed only by experienced persons, **as directed**. Conduct operations in strict accordance with applicable regulations. Protect exposed structures from the effects of the blast in accordance with the protection plan

E. Artificial Obstructions
1. Except as indicated, the Owner has no knowledge of cables, pipes, or other artificial obstructions or of any wrecks, wreckage, or other material that would necessitate the use of explosives or the employment of additional equipment for economical removal. If actual conditions differ from those stated or shown, or both, an adjustment in contract price or time for completion, or both, will be made.
OR
The Owner has knowledge of debris such as, but not limited to, metal bands, pallets, pieces of broken cable, rope, fire hose, and broken piles. The Owner has no knowledge of existing wrecks, wreckage, or other material of such size or character as to require the use of explosives or special or additional plant for its economical removal. Prior to dredging, the Contractor shall rake the dredge areas and shall remove debris encountered. Debris removed from the dredged area shall be removed from the water. Disposal shall be the responsibility of the Contractor and disposal shall be outside the limits of government property. In case the actual conditions differ from those stated or shown, or both, an adjustment in contract price or time of completion, or both, will be made.

F. Side Slopes
1. Dredging on side slopes shall follow, as closely as practicable, the lines indicated or specified. An allowance will be made for dredging beyond the lines indicated or specified for side slopes. The allowance will be determined by projecting a line upwards, paralleling the project design side slopes, from the intersection of the overdepth dredging limit (at a point located vertically below the limit of dredging at the top of slope). The amount of material excavated from side slopes will be determined by either cross-sections or computer, or both.

G. Permit
1. The Contractor shall comply with conditions and requirements of State or Federal permits. the Owner will secure the permit for dredging and disposal of material as indicated. Make arrangements for disposal of excavated materials.

H. Environmental Protection Requirements
1. Provide and maintain during the life of the contract, environmental protective measures. Also, provide environmental protective measures required to correct conditions, such as oil spills or debris, that occur during the dredging operations. Comply with Federal, State, and local regulations pertaining to water, air, and noise pollution.

1.2 PRODUCTS - (Not Used)

1.3 EXECUTION

A. Conduct Of Dredging Work
1. Order of Work Interference with Navigation: Minimize interference with the use of channels and passages. the Owner will direct the shifting or moving of dredges or the interruption of dredging operations to accommodate the movement of vessels and floating equipment, if necessary.
2. Compensation for Interruption of Operations: If dredging operations are interrupted due to the movement of vessels or floating equipment, an adjustment in the contract price or time for completion, or both, will be made as provided by the contract. the Owner will notify the Contractor 7 days prior to ship movements that will affect dredging operations.
3. Lights: Each night, between sunset and sunrise and during periods of restricted visibility, provide lights for floating plants, pipelines, ranges, and markers. Also, provide lights for buoys that could endanger or obstruct navigation. When night work is in progress, maintain lights from sunset to sunrise for the observation of dredging operations. Lighting shall conform to United States Coast Guard requirements for visibility and color.
4. Ranges, Gages, and Lines: Furnish, set, and maintain ranges, buoys, and markers needed to define the work and to facilitate inspection. Establish and maintain gages in locations observable from each part of the work so that the depth may be determined. Suspend dredging when the gages or ranges cannot be seen or followed. the Owner will furnish, upon request by the Contractor, survey lines, points, and elevations necessary for the setting of ranges, gages, and buoys.
5. Plant: Maintain the plant, scows, coamings, barges, pipelines, and associated equipment to meet the requirements of the work. Promptly repair leaks or breaks along pipelines. Remove dredged material placed due to leaks and breaks.
6. Disposal of Excavated Material: Provide for safe transportation and disposal of dredged materials. Transport and dispose of dredged material in the area designated for disposal of dredged material.

OR

The Contractor may, at his option, dispose of dredge material at an approved disposal area. The deposit of dredged materials in unauthorized places is forbidden. Comply with rules and regulations of local port and harbor governing authorities.

a. Method of Disposal: Deposit dredged material by the hydraulic process **OR** hopper dredge **OR** self-dumping scow or barge, **as directed**. Pipeline for hydraulic dredging shall discharge into the disposal area.
b. Disposal in Indicated Fill Areas: In depositing excavated material for fill, uniformly grade and allow for shrinkage. Provide and maintain necessary bulkheads, dikes, ditches, weirs, spillways, and other construction necessary to confine and retain the fill in the dredge fill area.
c. Operation of Sluiceways: Sluiceways on the disposal area levees will be operated and maintained by the Owner. The Contractor will be relieved of operations thereof.

d. Submerged Pipeline: If a leak occurs in the discharge pipeline, immediately discontinue using the line until leaks are repaired. Remove material placed due to leaks or breaks.

7. Navigation Warnings: Furnish and maintain navigation warning signs along the pipeline.
8. Method of Communication: Provide a system of communication between the dredge crew and the crew at the disposal area. A portable two-way radio is acceptable.
9. Salvaged Material: Anchors, chains, firearms, and other articles of value, which are brought to the surface during dredging operations, shall remain or become the property of the Owner and shall be deposited on shore at a convenient location near the site of the work, as directed.
10. Safety of Structures: The prosecution of work shall ensure the stability of piers, bulkheads, and other structures lying on or adjacent to the site of the work, insofar as structures may be jeopardized by dredging operations. Repair damage resulting from dredging operations, insofar as such damage may be caused by variation in locations or depth of dredging, or both, from that indicated or permitted under the contract.
11. Plant Removal: Upon completion of the work, promptly remove plant, including ranges, buoys, piles, and other markers or obstructions.

B. Measurement

1. Contractor shall take soundings before and after dredging.
   a. Method of Measurement: The material removed will be measured by means of soundings taken before and after dredging. The drawings represent existing conditions based on current available information, but will be verified and corrected, if necessary, by soundings taken before dredging in each locality. Soundings will be taken by lead line or 200 kHz sonic methods, or both, as determined by the Owner; results of soundings by either or both methods will be the basis for payment. Areas sounded more than 30 days prior to dredging will be re-sounded when requested by the Contractor. The Contractor has the option of being present when such soundings are made.
   b. Surveys During Progress of Work: Contract depth will be determined by soundings or sweepings taken behind the dredge as work progresses. The Contractor shall take progress soundings or sweepings.

C. Final Examination And Acceptance

1. As soon as practicable after the completion of areas, which in the opinion of the Owner, will not be affected by further dredging operations, each area will be examined by the Owner by sounding or sweeping, or both. Remove shoals and lumps by dragging the bottom or by dredging. However, if the bottom is soft and the shoal areas form no material obstruction to navigation, removal may be waived at the discretion of the Owner. The Contractor will be notified when soundings or sweepings are to be made and will be permitted to accompany the sounding or sweeping party and to inspect the data and methods used in preparing the final estimate. When areas are found to be in a satisfactory condition, the work therein will be accepted as complete. Final estimates will be subject to deductions or correction of deductions previously made because of excessive overdepth, dredging outside or authorized areas, or disposal of material in an unauthorized manner.

END OF SECTION 35 24 23 00

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Task	Specification	Specification Description
35 24 26 00	01 22 16 00	No Specification Required

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Task	Specification	Specification Description
40 05 23 23	21 05 23 00	Piped Utilities Basic Materials And Methods
40 05 23 23	23 11 23 00	Relief Wells
40 05 23 23	23 11 23 00a	Monitoring Wells
40 05 23 23	22 11 23 23	Water Supply Wells
40 05 23 23	22 05 76 00	Sanitary Sewerage
40 05 23 23	07 63 00 00	Common Work Results for Fire Suppression
40 05 23 23	07 63 00 00a	Common Work Results for Plumbing
40 05 23 23	07 63 00 00b	Common Work Results for HVAC

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SECTION 41 22 23 13 - MATERIAL HANDLING HOISTS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of material handling hoists. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Electric Chain Hoists
1. Hoist motors shall be H4 duty classification. Class F insulation shall be used in hoist motor for 30 minute operation. Load chain shall be grade 80 alloy, case hardened and zinc plated sized for the intended load. Hoists shall employ AC motor brakes employing single or multiple all-steel disks. Controls shall be hand-held, low voltage electrical, with emergency shut off and enclosed in NEMA 3R rated weatherproof enclosure. Hoist shall include fail safe limit switches in the hoist enclosure. Hoist shall meet requirements of ANSI B30.16 standard. Load hook shall be heavy-duty drop forged with safety latch. Hoist shall have swivel top and bottom hooks.

B. Manual Chain Hoists
1. Load capacity of hoist shall be as specified. Load chain shall be grade 80 alloy, case hardened and zinc plated sized for the intended load. Load hook shall be heavy-duty drop forged with safety latch. Hoist mechanism shall be double pawl ratchet system with Weston type brake using a non-asbestos friction disk. Hoist shall have swivel top and bottom hooks. Hoist shall require between 50 and 80 pounds effort to move load.

C. Electric Wire Rope Hoists
1. Hoist motors shall be H4 duty classification. Class F insulation shall be used in hoist motor for 30 minute operation. Lift range shall be between 20 and 150 feet. Lifting cable shall be pre-formed wire rope, of hoisting service construction, made of extra improved steel (XIP) with an independent wire rope center. Load hook shall be heavy-duty drop forged with safety latch. Hoist shall have swivel top and bottom hooks. Controls shall be hand held, low voltage electrical, with emergency shut off and enclosed in NEMA 3R rated weatherproof enclosure. Hoist shall include fail-safe limit switches in the hoist enclosure. Hoist shall meet requirements of ANSI B30.16 standard.

1.3 EXECUTION

A. Installation
1. The Contractor shall complete the assembly of any equipment furnished partially assembled and place the items in position as directed. The hoists shall be assembled and securely bolted in position, hoisting chain or wire rope installed, and the hoist made ready for regular operation. The Contractor shall furnish all miscellaneous hardware items required to complete the installation of all equipment and components. Equipment shall be primed and finish painted with a suitable corrosion-resistant paint on all parts and components not made of corrosion-resistant materials or otherwise protected.

END OF SECTION 41 22 23 13

SECTION 41 22 23 13a - MONORAILS WITH AIR MOTOR POWERED HOIST

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for monorails with air motor powered hoist. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Verification Of Dimensions
1. The Contractor shall be responsible for the coordination of his work with the work of all trades involved and as it relates to the building structure. The Contractor shall verify all building dimensions that relate to fabrication of the monorail system, and shall notify the the Owner of any discrepancy before order to the monorail manufacturer is finalized.

C. Submittals
1. Shop Drawings
2. Design Data
3. Test Reports
4. Certificates
5. Operation and Maintenance Data

D. Quality Assurance
1. Drawings: Submit drawings showing the general arrangement of the track beam system, including curves and switches, clearances, principal dimensions, details of structural connections, air system details, and all component details. Manufacturer's catalog data will suffice for items of standard manufacturer.
2. Certificates: Submit certification of minimum wire rope breaking strength for each hoist. Where applicable, submit factory certification of the load chain rated capacity.
3. Design Data: Submit design calculations verifying the size of structural members, structural supports (fittings, rods, brackets, and components), and lifting beams for the track beam system. The calculations shall include stress and loading diagrams. Submit calculations with monorail drawings.

E. Maintenance: Submit data package for the entire monorail system.

1.2 PRODUCTS

A. Fabrication And Construction
1. The hoist and trolley shall conform to ANSI/ASME HST-5M or ANSI/ASME HST-6M, **2 OR 3 OR** 5, **as directed**, ton (2 **OR** 3 **OR** 5, **as directed**, metric ton), for general service **OR** protected indoor **OR** all weather outdoor, **as directed**, (0 degrees to 100 degrees F (-18 to 38 degrees C)) working conditions. 2 ton (2 metric ton) design criteria shall apply to hoists of 2 ton (2 metric ton), or less, rated lifting capacity. Hoists of 2, 3, or 5 ton (2, 3, or 5 metric ton) rated capacity, shall be equipped with an automatic mechanical load lowering brake.
2. Capacity: The hoist shall have a minimum rated capacity as required to meet project requirements. The monorail system shall have a minimum rated capacity as required to meet project requirements.
3. Hook Lift and Speed: Shall be the manufacturer's standard within the limits specified in ANSI/ASME HST-5M or ANSI/ASME HST-6M. The hook lift shall be at its highest point a minimum height as required to meet project requirements above the finished floor and at its lowest point a minimum as required to meet project requirements below the finished floor.

OR

B. Fabrication And Construction

1. The 1/4 **OR** 1/2 **OR** 1, **as directed**, ton (1/4 **OR** 1/2 **OR** 1, **as directed**, metric ton) hoist and trolley shall meet the design requirements specified in ANSI/ASME HST-5M or ANSI/ASME HST-6M for the 2 ton (2 metric ton) hoist trolley.
2. Capacity: The hoist shall have a minimum rated capacity as required to meet project requirements. The monorail system shall have a minimum rated capacity as required to meet project requirements.
3. Hook Lift and Speed: For 1/4 **OR** 1/2 **OR** 1, **as directed**, ton (1/4 **OR** 1/2 **OR** 1, **as directed**, metric ton) hoist(s), the hook lift shall be at its highest point a minimum height as required to meet project requirements above the finished floor and at its lowest point a maximum **OR** minimum, **as directed**, as required to meet project requirements above **OR** below, **as directed**, the finished floor. The hook lift and speed limits for 1/4 **OR** 1/2, **OR** 1 ton, **as directed**, (1/4 **OR** 1/2 **OR** 1, **as directed**, metric ton) rated capacity hoists shall be within the limits shown in the following table.

Standardized hoist lift ranges and rated lifting speed ranges for 1/4, 1/2, and 1 metric ton rated capacity

Rated load Capacity (metric tons)	Hoist lift range (meter)	Hoist lifting speed range (mm/s)	
		Low	High
1/4	3 to 15	120	350
1/2	3 to 12	80	250
1	3 to 10	40	225

Standardized hoist lift ranges and rated lifting speed ranges for 1/4-, 1/2-, and 1-ton rated capacity

Rated load capacity (tons)	Hoist lift range (feet)	Hoist lifting speed range (feet per minute)	
		Low	High
1/4	10 to 50	24	70
1/2	10 to 40	16	50
1	10 to 30	8	45

4. Hooks: Shall be of the safety type with hook nuts keyed to hook shanks by means of a setscrew installed in a plane parallel to the longitudinal axis of the hook shank, or by any other similar easily removable securing device. All hook components shall be magnetic-particle inspected over the entire area in accordance with ASTM A 275/A 275M. The acceptance standard shall be one of no defects. A defect is defined as a linear indication revealed by magnetic-particle inspection that is greater than 1/8 inch (3 mm) long whose length is equal to or is greater than three times its width.
5. Hoist Wire Rope: Rope lengths shall be sufficient to maintain a minimum of two full wraps of rope at the dead end(s) of the drum, with the block in its lowest indicated position.
6. Hoist Chain: Chain hoists of 10 foot (3 m) lift or more shall be equipped with a load chain bucket.
7. Hoist Limit Switch: Hoists shall be equipped with upper and lower hoist limit switches/devices.
8. Control Pendant: Shall extend as required to meet project requirements below the underside of the track beam.
9. Trolley: Shall have a manual **OR** geared manual **OR** air motor powered, **as directed**, drive and shall be designed to operate from track beam section. Where two or more hoists are located on the same monorail beam, the trolleys shall be equipped with rubber bumper devices designed to prevent contact of any part or parts of the hoists.

C. Monorail Track Beam System
1. Shall conform to MMA MH27.1, for powered hoists. The maximum allowable deflection shall not exceed 1/600 of the unsupported span, with the hoist(s) at rated load(s) and at any location(s). The track beam system shall have trolley stops at all open end locations. The stops shall be designed to retain the hoist on the track. Wheel stops shall interface with the trolley wheel treads on both sides of the track web simultaneously and shall not interface with the trolley wheel flanges. The air supply valve specified shall be of the quick shutoff type, readily accessible from the floor, and located within proximity to the monorail system.
2. Color of Finished Equipment: Shall be the manufacturer's standard brilliant yellow.
3. Identification Plates: The manufacturer shall furnish and install identification plates of noncorrosive metal. Information and data on the plates shall include, in clearly legible permanent lettering, the manufacturer's name, model number, capacity rating, and other essential information. In addition, the monorail track beam system shall be furnished with identification plates showing the capacity of the system, which shall be legible from the floor and from either side of the monorail track beam.

1.3 EXECUTION

A. Erection And Installation
1. The Contractor shall erect and install the hoist and monorail system in accordance with of MMA MH27.1. The monorail supplier shall provide supervisory erection services.

B. Field Inspection And Tests
1. Pre-Erection Inspection: Before erection, the Contractor and the manufacturer's representative shall jointly inspect the monorail and hoist systems and components at the job site to determine compliance with specifications and manufacturer's data and detail drawings as approved. The Contractor shall notify the the Owner 3 days before the inspection.
2. Load Tests: Upon completion, and before final acceptance, the hoist, trolley, and monorail shall be tested in operation as specified, carrying 125 percent of the rated capacity, and with the units spaced to obtain maximum possible loads in the monorail track beam systems. The air equipment will not necessarily operate at rated speed with a 125 percent overload. For hoists that incorporate mechanical load brakes, the mechanical load brake shall hold a static, as well as control a dynamic, 125 percent rated load. The systems shall be thoroughly tested in service to determine that each component of the system operates as specified, is properly installed and adjusted, and is free from defects in material, manufacture, installation, and workmanship. The Contractor shall furnish test loads, operating personnel, instruments, and other apparatus as necessary to conduct field tests on hoist and monorail. The test and final adjustments of the equipment shall be under the supervision of the the Owner. The Contractor shall rectify any deficiencies found and completely retest work affected by such deficiencies.

END OF SECTION 41 22 23 13a

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SECTION 41 22 23 13b - MONORAILS WITH ELECTRIC POWERED HOISTS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for monorails with electric powered hoists. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. System Description
1. Provide a monorail system with electric powered hoist(s) and plain type (hand operated) **OR** hand chain operated **OR** electric powered, **as directed**, trolley(s) complete, tested and ready for operation. Monorails, hoist(s), trolley(s), equipment, materials, installation, examination, inspection, and workmanship shall be in accordance with the applicable requirements of NFPA 70, ASME/ANSI B30.11, ASME/ANSI B30.16, ASME HST-1M, ANSI/ASME HST-4M, and MMA MH27.1, with modifications specified herein. Reference in these publications to the "authority having jurisdiction" shall be interpreted to mean the "the Owner."

C. Submittals
1. Shop Drawings: Monorail system
2. Product Data: Monorail track system including switches, suspension system and other components; Electric wire rope hoist; Electric chain hoist; Trolley; Pendant pushbutton station; Electrification.
3. Design Data: Load and sizing calculations.
4. Test Reports
5. Certificates
6. Operation and Maintenance Data

D. Delivery, Storage, and Handling
1. Delivery and Storage: Inspect materials delivered to site for damage; unload and store with minimum handling. Store materials on-site in enclosures or under protective coverings. Protect materials not suitable for outdoor storage to prevent damage during periods of inclement weather, including subfreezing temperatures, precipitation, and high winds. Store materials susceptible to deterioration by direct sunlight under cover and avoid damage due to high temperatures. Do not store materials directly on ground. When special precautions are required, prominently and legibly stencil instructions for such precautions on outside of equipment or its crating.
2. Handling: Handle materials in such a manner as to ensure delivery to final location in undamaged condition. Make repairs to damaged materials at no cost to the Owner.

E. Quality Assurance
1. Certificates: Overload Test Certificate: Submit a statement that the monorail system can be periodically load tested to 125 percent (plus 5 minus 0) of rated load.
2. Drawings: Monorail System: Show the general arrangement of all components, clearances and principal dimensions, assemblies of hoist, trolley, track, track suspension system, and electrical schematic drawings.
3. Design Data: Load and Sizing Calculations: Submit calculations verifying the sizing of any track, track suspension device and additional supports which are not the monorail system manufacturer's standard cataloged product.

1.2 PRODUCTS

A. Overhead Monorail System: Provide overhead monorail system conforming to MMA MH27.1, Class C, for indoor **OR** outdoor, **as directed**, service, with an electric wire rope or chain hoist mounted on a movable trolley. Trolley shall be plain type (hand operated) **OR** hand chain operated **OR** motor operated, **as directed**. Monorail system shall operate on AC voltage as required to meet project requirements, 60 Hz, single **OR** three, **as directed**, phase power source.

1. Capacity: The monorail system shall have a minimum rated capacity as required to meet project requirements. Mark the hoist capacity in pounds (kg) on both sides of the hoist or load block.
2. Speeds: The hoist shall have two operating speeds, **unless directed otherwise,** and shall be capable of hoisting and lowering the rated load at a high speed of 20 feet per minute (fpm) (100 mm/s). The trolley shall have two operating speeds, **unless directed otherwise,** and shall be capable of moving the rated load at a high speed of 50 fpm **OR** 100 fpm, **as directed**, (250 mm/s **OR** 500 mm/s, **as directed**,). Low speed(s) shall be one quarter to one third of high speed(s). Actual speed(s) shall be within plus or minus 15 percent of those specified.
3. Material Limitations: Shafts, keys, couplings, sprockets, and chains shall be steel. All gears shall be steel except for worm gears, which shall be bronze or steel. Cast iron and aluminum used to support components of the hoist power transmission train shall be ductile.
4. Safety: Comply with the mandatory and advisory safety requirements of ASME/ANSI B30.11, ASME/ANSI B30.16, and 29 CFR 1910.179.

B. Monorail Track System: MMA MH27.1. Track beams shall be patented track sections fabricated by a manufacturer regularly engaged in production of this type of beam.

1. Track Suspension System: Monorail suspension shall be flexible **OR** rigid, **as directed**, type. Make bolted connections to supporting structure, excluding hanger rods, with ASTM A 325/A 325M bolts, ASTM A 563/A 563M nuts, and ASTM F 959/F 959M load indicator washers. ASTM A 325/A 325M bolts shall be fully pre-tensioned in accordance with AISC S329. Support monorail track system from the structural members shown. Provide additional supports as required to carry monorail track system loads to the structural members shown. Materials for additional supports shall conform to the material requirements contained in Division 05 Section "Structural Steel Framing".

C. Electric Wire Rope Hoist: ANSI/ASME HST-4M, Class H3, except as modified herein. Hoist shall be double reeved, **unless directed otherwise**.

1. Hoisting Ropes: FS RR-W-410, improved or extra improved plow steel, regular lay, uncoated, 6 by 37 class construction, with an independent wire rope core. Provide proof of wire rope breaking strength test report.
2. Sheaves: Sheaves shall be steel or ductile cast iron. Pitch diameter of running sheaves shall not be less than 16 times the rope diameter. Pitch diameter of non running sheaves shall not be less than 12 times the rope diameter.
3. Drum: Drum shall be steel or ductile cast iron. Pitch diameter of the drum shall not be less than 18 times the rope diameter. Not less than two dead wraps of the hoisting rope shall remain on each anchorage when the hook is in its extreme low position.

D. Electric Chain Hoist: ASME HST-1M, Class H3, except as modified herein. Provide load chain proof test.

E. Trolley: Trolley shall meet all applicable requirements of MMA MH27.1, ASME HST-1M and ANSI/ASME HST-4M. Trolley shall have elastomeric bumpers to engage runway stops.

F. Motors: NEMA MG 1. Hoist motor shall be single **OR** two, **as directed**, speed AC squirrel cage induction type. Trolley motor shall be single **OR** two, **as directed**, speed AC squirrel cage induction type. Motor insulation shall be Class B minimum. Provide totally enclosed non-ventilated (TENV) motor enclosures. Maximum motor speed shall not exceed 1800 RPM.

G. Controls: Provide single **OR** two, **as directed**, speed magnetic control for the hoist. Provide single **OR** two, **as directed**, speed magnetic controls for the trolley. Provide reduced voltage starting, acceleration and deceleration for the trolley drive.

H. Limit Switches: Provide upper and lower limit switches which de-energize the hoist motor.

I. Brakes: Provide hoist with an electro-mechanical holding brake and a mechanical load brake, each capable of holding 130 percent of the rated hoist capacity. Hoist holding brake shall be capable of being released to test the load brake. Provide trolley with an electro-mechanical brake. Provide trolley brake with a minimum torque rating of 100 percent (for outdoor monorails) or 50 percent (for indoor monorails) of the drive motor rated torque. Trolley brake torque shall be adjustable down to 85 percent of its torque rating.

J. Load Block And Hook: Construct load blocks of steel. Provide forged steel, swivel type hook, with hook nut keyed to hook shank by means of a setscrew installed in a plane parallel to the longitudinal axis of the hook shank, or other similar easily removable securing device. Hook throat opening shall not be less than as required to meet project requirements. Provide hook with spring loaded steel safety latch for closing the hook throat opening. The hook and hook nut shall be unpainted. Permanently mark hook and hook nut with an identification number.
   1. Hook and Hook Nut Magnetic Particle Inspection: Magnetic particle inspect the hook and nut over the entire area in accordance with ASTM A 275/A 275M. Acceptance standard shall be no defects. A defect is defined as a linear indication that is greater than 1/8 inch (3 mm) long whose length is equal to or greater than three times it width.

K. Bearings: All bearings except those subject to a small rocker motion shall be anti-friction type. Bearings not considered lifetime lubricated by the manufacturer shall be provided with a means for lubrication.

L. Pendant Pushbutton Station: Hoist and trolley, **unless directed otherwise,** shall be controlled from a pendant pushbutton station. Arrange pushbuttons in accordance with ASME/ANSI B30.11recommendations. Locate station 4 feet (1.2 m) above the finished floor

M. Electrification: Runway electrification shall be of the flat festooned type **OR** enclosed safety bar type, **as directed**, with four continuous copper conductors. Provide electrical work for the monorail system in accordance with NFPA 70.

N. Identification Plates: Provide identification plates of noncorrosive metal with clearly legible permanent lettering giving the manufacturer's name, model number, capacity in pounds, and other essential information or identification.

O. Painting System: Painting shall be manufacturers standard. Provide a primer and a finish coat. For outdoor monorail systems, blast clean all components prior to painting and prime with inorganic zinc type primer; finish coat shall be an epoxy formulated for marine environments. Paint coats shall be smooth and even, free of runs, sags, orange peel, or other defects.

1.3 EXECUTION:

A. Erection And Installation: Erect and install the monorail system, complete in accordance with the approved submittals and in condition to perform the operational and acceptance tests.

B. Erection Services: Provide supervisory erection services from the monorail system manufacturer.

C. Field Quality Control
   1. Post-Erection Inspection: After erection, the Contractor and the the Owner shall jointly inspect the monorail and hoist systems and components to determine compliance with specifications and

approved submittals. The Contractor shall notify the the Owner 3 days before the inspection. Provide a report of the inspection indicating the monorail system is considered ready for operational tests

2. Operational Tests: After erection and inspection, test the hoist, and trolley as specified herein. Test the systems in service to determine that each component of the system operates as specified, is properly installed and adjusted, and is free from defects in material, manufacturer, installation, and workmanship. Rectify all deficiencies disclosed by testing and retest the system or component to prove the monorail system is operational. The Contractor shall furnish loads for testing, operating personnel, instruments, and all other necessary apparatus. The the Owner will furnish loads for testing; the Contractor shall receive and transport the loads from a location not more than 100 miles (161 km) from the job site and shall return them to that location after the tests have been completed.
3. Test Data: Record test data on appropriate test record forms suitable for retention for the life of the monorail system. Record operating and startup current measurements for electrical equipment (motors and coils) using appropriate instrumentation (i.e., clamp-on ammeters). Compare recorded values with design specifications or manufacturer's recommended values; abnormal differences (i.e., greater than 10 percent from manufacturer's or design values) shall be justified or appropriate adjustments performed. In addition, high temperatures or abnormal operation of any equipment or machinery shall be noted, investigated, and corrected. Record hoist and trolley speeds during each test cycle.
4. Hook Test: Measure hook for hook throat spread before and after load test. Establish a throat dimension base measurement by installing two tram points and measuring the distance between these tram points (plus or minus 1/64 inch (0.4 mm)). Record this base dimension. Measure the distance between tram points before and after load test. An increase in the throat opening by more than 5 percent from the base measurement shall be cause for rejection.
5. No-Load Test
   a. Hoist: Raise the load hook the full operating lift distance and verify satisfactory operation of hoist, upper limit switch, lower limit switch, and the hoisting and lowering speeds. Operate the hoist at low and high speed in both directions.
   b. Trolley: Operate trolley assembly the full length of the monorail in both directions. Operate trolley at low and high speed in each direction. Verify satisfactory operation and verify trolley speed. Operate all rail switches.
6. Load Test: 125 Percent (plus 5 percent minus 0) of rated capacity
   a. Hoist Static Test: Raise test load approximately one foot above the floor and hold for 10 minutes. Observe load lowering that may occur which will indicate malfunction of hoisting component or brake. Lower the test load to the floor until the hoist line is slack.
   b. Hoist Dynamic Test: Raise the test load to approximately 5 feet (1.5 m) above the floor using both speed points in the process. Lower the load back to the floor using both speed points. Stop the test load at least once while lowering at high speed and observe proper brake operation. Wait 5 minutes, then repeat the above cycle.
   c. Load Brake Test: Raise test load approximately 5 feet (1.5 m). With the hoist controller in the neutral position, release the holding brake. The load brake should hold the test load. Again with the holding brake in the released position, start the test load down at low speed and return the controller to off position as the test load lowers. The load brake should prevent the test load from accelerating. NOTE: It is not necessary for the load brake to halt the downward motion of the test load.
   d. Loss of Power Test: Raise the test load approximately 3 feet (1 m) and while lowering test load at low speed, cut main power to hoist. Load should stop.
   e. Trolley Test: With test load hoisted to a height of one foot (300 mm) above the floor, operate trolley the full distance of the monorail in both directions using both speed points in the process. Observe for any malfunctioning of the trolley assembly and monorail system. Operate all rail switches.
   f. Rated Load Speed Test: With the hoist loaded to rated capacity, raise and lower the load verifying that the hoisting and lowering speeds are provided as specified. With the hoist loaded to rated capacity, operate trolley along the monorail beam verifying that the trolley

speed is provided as specified. Further, verify that the trolley stops in each direction within a distance (in feet) equal to 10 percent of rated capacity high speed (in feet per minute) when initially travelling at high speed and carrying the rated capacity load. Record voltage, amperage, hoisting and lowering speeds, trolley travel speed, and motor speed for each motor.

END OF SECTION 41 22 23 13b

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SECTION 41 22 23 13c - MONORAILS WITH MANUAL HOIST

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for monorails with manual hoist. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Verification Of Dimensions:
1. The Contractor shall verify all building dimensions that relate to fabrication of the monorail system, and shall notify the Owner of any discrepancy before the order to the monorail manufacturer is finalized.

C. Submittals
1. Shop Drawings: Submit drawings showing the general arrangement of the track beam system, including curves and switches, clearances, principal dimensions, details of structural connections, and all component details. Manufacturer's catalog data will suffice for items of standard manufacturer.
2. Design Data: Structural design calculations.
3. Test Reports
   a. Hook and hook nut magnetic-particle tests.
   b. Monorail system load tests
4. Certificates: Manual hoist load chain
5. Operation and Maintenance Data
   a. Track beam system
   b. Hoist and trolley

D. Quality Assurance
1. Certifications: Submit factory certification of load chain rated capacity.
2. Design Data: Submit design calculations verifying the size of structural members, structural support fittings, rods, brackets, components, and lifting beams for the track beam system. The calculations shall include stress and loading diagrams. Submit calculations with monorail drawings.

1.2 PRODUCTS

A. Fabrication And Construction: Provide manual hoist and trolley, ANSI/ASME HST-2M, ANSI/ASME HST-3M, trolley suspension. Trolley and wheels shall be suitable for operation on the steel monorail track beam provided, and shall have not less than four wheels.
1. Capacity: The hoist shall have a minimum rated capacity as required to meet project requirements. The monorail system shall have a minimum rated capacity as required to meet project requirements.
2. Hook Lift: Shall be the manufacturer's standard. The hoist lift shall be at its highest point a minimum of 8 feet (2400 mm) above the finished floor and at its lowest point a minimum of 2 feet (600 mm) below the finished floor.
3. Hooks: Shall be of the safety type with hook nuts keyed to hook shanks by means of a setscrew installed in a plane parallel to the longitudinal axis of the hook shank, or by any other similar easily removable securing device. All hook components shall be magnetic-particle inspected over the entire area in accordance with ASTM A 275/A 275M. The acceptance standard shall be one of no defects. A defect is defined as a linear indication revealed by magnetic-particle

inspection that is greater than 1/8 inch (3 mm) long whose length is equal to or is greater than three times its width.

4. Trolley: Shall be designed to operate from track beam section. Where two or more hoists are located on the same monorail beam, the trolleys shall be equipped with rubber bumper devices designed to prevent contact of any part or parts of the hoists.
5. Load Chain: High strength steel links, flexible; minimum safety factor of 5 to 1 based on ratio of minimum chain breaking load to the calculated load on the chain when the hoist is assumed loaded to rated capacity. Certification from hoist manufacturer of provided chain's breaking strength shall be submitted to the Owner and approved prior to final acceptance of hoist. Do not paint or coat the load chain.
6. Load Hooks and Load Hook Components
   a. Hook: Forged steel; complete with spring-loaded steel throat opening safety device. The hook shall be carried on suitably sealed or shielded anti-friction thrust bearings and shall swivel freely through 360 degrees rotation with full load without twisting chain.
      1) Disassembly. Hook and hook nut shall be capable of complete disassembly that enables access to all surfaces of the hook, including shank and hook nut for inspection purposes. Provision shall be made for the hook nut, or other hook-to-block fastener, to be keyed to hook shank by means of a set screw or similar, easily removable, securing device.
      2) Hook Non-Destructive Test. Each hook, including shank and hook nut, shall be inspected over the entire surface areas by magnetic particle inspection. If hook nut is not used, any device that functions the same as the hook nut shall be inspected by magnetic particle inspection.
         a) Procedure: Magnetic particle inspection shall be conducted in accordance with ASTM A 275/A 275M. This inspection shall be conducted at the factory of the hook manufacturer or hoist manufacturer. Alternately, a recognized independent testing lab may conduct the inspections if equipped and competent to perform such a service, and if approved by the the Owner.
         b) Acceptance Criteria: Defects found on the hook or hook nut shall result in rejection of defective items for use on furnished hoist. For this inspection, a defect is defined as a linear or non-linear indication for which the largest dimension is greater than 1/8 inch (3 mm). Weld repairs for defects on hook or hook nut will not be permitted.
         c) Test Report: A test report of the magnetic particle inspection of each hook and hook nut provided shall be submitted to and approved by the the Owner prior to final acceptance of hoist installation. Test reports shall be certified by the testing organization.

B. Monorail Track Beam System: Comply with MMA MH27.1 except as modified and supplemented herein.
   1. Patented Track: Provide specially designed trackage, e.g., patented track beam, curves, and switches constructed from welded steel components. The lower flange of the track section shall have flat wheel treads; minimum lower flange width of 3.25 inches (80 mm); chemical composition of 0.45 to 0.60 percent carbon content, 0.60 to 1.1 percent manganese content; and wheel treads shall be hardened to a minimum Brinell Hardness Number of 225. Upper flange and web of the track section shall be steel, continuously welded together or provided as one monolithic piece.
   2. Track Suspension: Provide means of suspending the monorail track system, including curves and switches from the structural supports. The suspension system shall be the sole responsibility of the track supplier; however, design shall be subject to the requirements specified herein.
      a. Cataloged Products: If possible, provide track manufacturer's standard cataloged devices for connection of the track to the indicated supporting structures. If track manufacturer's cataloged devices are not provided for this suspension system, complete shop drawings and calculations for the custom suspension device shall be submitted for review and approval by the the Owner. Track suspension devices which are not the track

manufacturer's cataloged products shall meet the additional requirements specified in Division 05 Section "Metal Fabrications".

b. Design: The suspension system shall be designed and constructed to ensure no impairment of the strength of track or the structural support. A hanger or suspension shall be located at each rack splice joint. Provide bracing to hold track sections in rigid alignment at all joints.

c. Suspension of Curves and Switches: Provide steel framing (structural supports), in addition to that indicated, as required by monorail curve and switch manufacturer to support curves and switches. The additional steel framing shall be the sole responsibility of the monorail supplier. Submit shop drawings and framing design calculations to the the Owner for approval.

d. Sway Bracing: Where the track is suspended from hanger rods, track shall be braced laterally and longitudinally to prevent sway.

e. Lock Nuts: Where the track is suspended from hanger rods, lock nuts or other means shall be provided to prevent the nuts from backing off the rods.

f. Multiple Suspension Devices: Where more than one suspension device attached to the track at a single point, the suspension devices shall be provided so that the loads shall be induced in each in proportion to the device's size.

3. Identification Plates: Provide identification plates of noncorrosive metal. Information and data on the plates shall include, in clearly legible permanent lettering, the manufacturer's name, model number, capacity rating, and other essential information. In addition, the monorail track beam system shall be furnished with identification plates showing the capacity of the system, which shall be legible from the floor and from either side of the monorail track beam.

C. Painting Of System: Provide manufacturer's standard painting or shop painting of components specified in this section; comply with the requirements specified in Division 07. Do not paint, coat, or galvanize load chain, load, hook nut, or load chain sheave.

1.3 EXECUTION

A. Erection And Installation: The Contractor shall erect and install the hoist trolley and monorail system in accordance with manufacturers written instructions, MMA MH27.1, and the contract drawings. The monorail supplier shall provide supervisory erection services. Welding new sections of monorail track to existing shall conform to AWS D1.1.

B. Field Inspection And Tests

1. Pre-Erection Inspection: Before erection, the Contractor and the manufacturer's representative shall jointly inspect the monorail and hoist systems and components at the job site to determine compliance with specifications and manufacturer's data and shop drawings as approved. The Contractor shall notify the the Owner 3 days before the inspection.

2. Operational Inspection and Load Tests: Upon completion, and before final acceptance, the hoist, trolley, and monorail shall be given the rated load test specified in ASME/ANSI B30.11, carrying 125 percent (plus 5 percent, minus 0 percent) of the rated capacity, and with the units spaced to obtain maximum possible loads in the monorail track beam systems. Hoists shall hold a static, as well as control a dynamic, 125 percent rated load. The systems shall be thoroughly tested in service to determine that each component of the system operates as specified, is properly installed and adjusted, and is free from defects in material, manufacture, installation, and workmanship. The Contractor shall furnish test loads, operating personnel, instruments, and all other necessary apparatus at no additional cost to the Owner. The test and final adjustments of the equipment will be under the supervision of the Owner. The Contractor shall rectify any deficiencies found and completely retest work affected by such deficiencies.

END OF SECTION 41 22 23 13c

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Task	Specification	Specification Description
43 23 78 31	21 05 23 00	Piped Utilities Basic Materials And Methods
43 24 41 23	21 05 23 00	Piped Utilities Basic Materials And Methods
43 42 41 00	01 22 16 00	No Specification Required

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Task	Specification(s)
01 22 16 00	01 22 16 00
01 22 20 00	01 22 16 00
01 22 23 00	01 22 16 00
01 51 13 00	01 51 13 00
01 52 13 00	01 52 13 00, 01 22 16 00
01 52 19 00	01 22 16 00, 01 52 13 00
01 53 16 00	01 22 16 00
01 54 23 00	01 54 23 00, 01 54 23 00a, 01 22 16 00
01 54 26 00	01 22 16 00
01 55 23 00	01 22 16 00
01 55 26 00	01 22 16 00
01 56 16 00	01 22 16 00
01 56 26 00	01 56 26 00, 01 56 26 00a, 01 22 16 00
01 56 29 00	01 22 16 00
01 56 33 00	01 22 16 00
01 56 39 00	01 22 16 00
01 57 13 00	01 56 26 00
01 58 13 00	01 58 13 00, 01 22 16 00
01 66 19 00	01 22 16 00
01 71 13 00	01 22 16 00
01 71 23 16	01 71 23 16
01 74 16 00	01 22 16 00
01 74 19 00	01 74 19 00, 01 22 16 00
02 32 13 00	02 32 13 00, 01 22 16 00
02 41 13 13	02 41 13 13, 02 41 13 13a
02 41 16 13	02 41 16 13, 02 41 13 13, 02 41 13 13a
02 41 19 13	01 71 23 16, 02 41 13 13, 02 41 16 13, 02 41 13 13a
02 41 19 16	02 41 13 13, 02 41 16 13, 02 41 13 13a
02 42 21 35	02 41 13 13
02 42 21 47	02 41 13 13
02 43 13 13	01 22 16 00
02 58 13 00	02 58 13 00, 02 58 13 00a
02 61 00 00	02 61 00 00
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02 61 26 00	02 61 26 00, 02 61 26 00a
02 65 00 00	02 41 13 13, 02 61 00 00, 02 61 13 00, 02 61 13 00a, 02 61 13 00b
02 81 00 00	02 61 00 00, 02 61 26 00
02 82 16 00	02 82 16 00
02 82 33 00	02 82 33 00, 01 22 16 00, 02 61 26 00, 02 61 26 00a, 02 82 16 00
02 83 19 13	02 83 19 13, 02 83 19 13a, 02 83 19 13b, 02 83 19 13c
02 83 33 13	02 83 19 13, 02 83 19 13a, 02 83 19 13b, 02 83 19 13c
02 84 16 00	02 84 16 00, 02 84 16 00a, 02 84 16 00b
02 84 33 00	02 84 33 00
02 86 00 00	02 41 13 13, 02 61 00 00, 02 61 13 00, 02 61 13 00a, 02 61 13 00b, 02 61 26 00
02 87 13 33	02 87 13 33
02 87 16 13	02 87 16 13
02 89 00 00	01 22 16 00, 02 83 19 13, 02 83 19 13a, 02 83 19 13b, 02 83 19 13c
02 90 50 00	01 22 16 00
03 01 30 71	03 01 30 71, 03 01 30 71a, 01 22 16 00
03 05 13 00	03 05 13 00
03 11 13 00	01 22 16 00, 03 05 13 00
03 11 16 13	03 11 16 13, 03 11 16 13a, 03 05 13 00
03 11 23 00	01 22 16 00, 03 05 13 00
03 15 13 13	03 05 13 00

Task	Specification(s)
03 15 13 16	03 05 13 00
03 15 16 00	03 05 13 00
03 15 19 00	05 50 00 00
03 21 11 00	03 05 13 00
03 21 16 00	03 05 13 00
03 22 11 00	03 05 13 00
03 22 13 00	03 05 13 00
03 22 16 00	03 05 13 00
03 30 53 00	03 05 13 00
03 31 13 00	03 31 13 00, 03 31 13 00a, 03 31 13 00b, 03 31 13 00c, 03 31 13 00d, 03 05 13 00
03 35 13 00	03 05 13 00
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03 35 19 00	03 05 13 00
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07 46 16 00	07 46 16 00, 07 46 16 00a, 07 41 13 00, 07 42 93 00
07 46 19 00	07 41 13 00, 07 46 16 00, 07 46 16 00a, 07 42 93 00
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33 01 34 13	21 05 23 00, 33 01 30 81
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