# LOS ANGELES INTERNATIONAL AIRPORT
# CONSOLIDATED RENTAL CAR FACILITY

# PROJECT MANUAL

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**VOLUME 4** OF 4

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# SPECIFICATIONS

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# SECTION 26 00 00
# AIRPORT ELECTRICAL DESIGN STANDARDS

## PART 1 – GENERAL

### 1.1 PURPOSE

A. The purpose of these Standards is to highlight the most important Electrical system items based on LAWA standards. The Standards are a compilation of general design and construction practices that are already in place in our facilities, as well as recent discoveries that shall be implemented throughout the facilities to maximize the performance of existing systems, minimize maintenance costs and improve the travelling public's experience. These Standards are by no means a complete description of all items practiced in our facilities. However, this document does represent LAWA's standards for most of the major electrical systems. The majority of these Standards are also found in the LAWA Design and Construction Handbook. If any discrepancy is found between these Standards and the Design and Construction Handbook, these Standards shall take precedence.

### 1.2 MEDIUM VOLTAGE CABLE

A. Conductor insulation level thickness shall be 133 percent.

B. Testing. Engage a qualified inspecting and testing agency to perform each visual and mechanical inspection and electrical testing in accordance to NETA ATS.

C. Provide cable pulling tension calculations.

### 1.3 LOW VOLTAGE POWER CONDUCTORS AND CABLES

A. #12 AWG feeder and branch circuit conductors shall be solid.

B. All other feeder and branch circuit conductors shall be stranded.

### 1.4 RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

### 1.5 CONDUIT

A. All conduits, cables and wiring shall be concealed from public view.

B. All conduits shall be Electrical Metallic Tubing (EMT) for building interior only and Rigid Galvanized Steel (RGS) for building exterior. RGS conduit shall be installed in all areas subject to physical damage.

C. Spare conduits shall be provided with pull lines and labels, feeder format.

D. The minimum conduit size shall be 3/4 inch.

E. Romex, MC cable and aluminum flex conduits are not allowed.

F. Label conduits with circuit information.

1.6 ENCLOSURES

A. Indoor dry enclosures shall be NEMA Type 1.

B. Outdoor enclosures shall be NEMA Type 4 or Type 3R stainless steel gasketed.

C. Enclosures exposed to dust or moisture shall be NEMA Type 12 or Type 3R/12.

1.7 IDENTIFICATION FOR ELECTRICAL SYSTEMS

1.8 NAMEPLATES ON EQUIPMENT

A. Engraved Plastic Nameplates and Signs: Engraving stock, melamine plastic laminate, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. in. (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes. Engraved legend with white letters on black face for normal power, white letters on red face for emergency power. Punched or drilled for mechanical fasteners. Text is at 1/2-inch (13 mm) high lettering

B. Nameplates shall adequately describe the function of the particular equipment involved. Where nameplates are detailed on the drawings, inscription and size of letters shall be as shown and shop drawing submitted for approval. Nameplates for panelboards and switchboards shall include the panel designation, voltage, phase and wire. The next item shall be either LAWA, Concessions, or Airline panel, depending on loads served. In addition, describe where the panel is fed from. For example:

PANEL 1LA, 120/208V, 3PH, 4W
LAWA PANEL
FED FROM MS

C. Nameplates shall be secured to equipment front using stainless steel screws or rivets.

D. Custom metal master nameplates shall be furnished and installed by the manufacturer on each distribution section, switchboard section and motor control center indicating the manufacturer's name, ampere rating, short-circuit rating (bus bracing) and date. Paper stickers are not acceptable. For example:

ABC SWITCHBOARD CO.
AMPERE RATING: 5000A
SHORT CIRCUIT RATING: 100KAIC
DATE: 01/01/2011

## 1.9 PANELBOARD DIRECTORIES

A. Panelboard directories shall be typewritten, arranged in numerical order, and shall list each circuit load and room number in which each load is located. Directories shall be mounted in a 6 by 8 inch metal frame under transparent plastic inside each panelboard door.

B. Changes to existing panelboard directories shall be made with a P-Touch or other label machine.

## 1.10 PERMANENT MARKING

A. All conduits, busways, cable trays and pullboxes shall be identified with permanent black letters and numbers which indicate the source panel (feeder supply source), circuit numbers, and designated panel or load. For example, "PA-1,3,5 TO MG." For conduits, the letter height shall be one-third (1/3) the conduit size with 1/4 inch minimum height. For pullboxes and busways, the letter height shall be 1/2 inch minimum height and not larger than 3/4 inch height.

B. The identifications for conduits, busways and cable trays shall be placed at every 50 feet intervals and within 10 feet of wall and floor penetrations, pullboxes, panels, distribution boards, switchboards, and electrical equipment.

C. Spare conduits, pullboxes, busways, and abandoned raceways (that are to remain as shown on the drawings) shall be identified as described above (A, B).

D. The permanent marking identifications on the raceways and pullboxes shall be visible after the installations are made.

E. All receptacle and switch faceplates shall be labeled with the source panel and circuit number. The label shall be black Arial font on white or clear tape, produced by a P-Touch or other label machine.

## 1.11 CONDUCTOR IDENTIFICATION

A. All power and branch circuit conductors shall be provided with color-coded insulation or color- coded self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide. Vinyl tape shall be used in vaults, pull and junction boxes, manholes and handholes. Identify the source and circuit number of each set of conductors with write-on tags.

B. Color coding shall be as follows:

| **Phase** | **208Y/120V** | **480Y/277V** |
|---|---|---|
| A | Black | Brown |
| B | Red | Orange |
| C | Blue | Yellow |
| Neutral | White | Gray |
| Ground | Green | Green |

## 1.12 UNDERGROUND WARNING TAPE

A. Description: Permanent, detectable, red colored, continuous printed, polyethylene tape with suitable warning legend describing buried electrical lines. Tape shall be minimum 6 inches wide by 4 mils thick. Other color codes include:

| | |
|---|---|
| Safety Red | Electric and lighting conduit and cables |
| Safety Yellow | Gas, oil, steam, petroleum, or gaseous materials |
| Safety Orange | Telephone, alarm, or signal cables and conduit |
| Safety Blue | Potable water or irrigation |
| Safety Green | Sewer or drain lines |

## 1.13 MANHOLE AND UNDERGROUND PULLBOX COVER LABEL

A. All manhole and underground pullbox covers shall have the following cast-in or bead welded and galvanized identification label permanently affixed to the exterior:

"ELEC-LV" for electrical power circuits 600 volts or less

"ELEC-HV" for electrical power circuits over 600 volts

"COMM" for communications circuits

B. A custom 3-digit number shall be added to the cover. Contact the Engineer for number assignment.

C. The minimum letter height shall be one (1) inch.

## 1.14 LOW VOLTAGE TRANSFORMERS

A. The equipment, major components and anchorage shall be suitable for and certified to meet all applicable seismic requirements defined in Division 26 Section Vibration and Seismic Controls for Electrical Systems.

B. Transformer coils shall be wound of electrical grade copper with continuous wound construction.

## 1.15 SWITCHBOARDS

A. Switchboards shall be "fully-rated" for the available short circuit current. "Series-rated" equipment is not acceptable. Main 480 volt service switchboards in the terminals shall be rated 100kAIC.

B. The manufacturer of the switchboard assembly shall be the same as the manufacturer of the circuit breakers installed within the assembly.

C. The equipment, major components and anchorage shall be suitable for and certified to meet all applicable seismic requirements defined in Division 26 Section Vibration and Seismic Controls for Electrical Systems.

D. Distribution bus bars shall be silver-plated or tin-plated copper and shall have bus extensions provided at the ends where future sections can be added. Bus bars shall be fully rated for the entire length of the switchboard.

E. Switchboards shall be positioned so there is open space on either side for future additional sections.

1.16 PANELBOARDS

A. Panelboards shall be "fully-rated" for the available short circuit current. "Series-rated" equipment is not acceptable.

B. The manufacturer of the panelboard assembly shall be the same manufacturer of the major components within the assembly, including the circuit breakers.

C. The equipment, major components and anchorage shall be suitable for and certified to meet all applicable seismic requirements defined in Division 26 Section Vibration and Seismic Controls for Electrical Systems.

D. Panelboard main bus bars shall be copper with full capacity neutral and equipment ground bus.

E. Panelboards shall be installed in rooms or areas not within public view.

1.17 MOTOR CONTROL CENTERS

A. Motor control center shall be heavy duty industrial grade.

B. All indicator and pilot lights shall be LED with metal housing and easily replaceable parts.

C. All control wiring shall be installed in Panduit wiring ducts. Wiring shall be stranded copper.

D. Provide wire markers or tags for all control wiring at all termination points.

E. Each plug-in unit shall control only one motor, no dual starters.

F. Provide a circuit breaker for the unit disconnect device, not a fusible switch.

G. Provide side mounted, latched pull-apart terminal blocks for all remote control wiring.

Provide 25% spare terminals.

H. No interlock for A-B motor configuration

I. Overload reset button shall be operable without wires blocking access

J. Provide three (3) position selector switch, Hand-Off-Auto, not Start-Stop button

K. For motors with two (2) speeds, provide a separate selector switch, High-Low.

L. Wire ties shall be attached to the unit with screws or epoxy, not adhesive tape.

1.18 ENCLOSED BUS ASSEMBLIES

A. All busway components shall be of the same manufacturer as the busway.

B. Indoor busway feeders shall be sprinkler-proof, IP54 rating.

C. The equipment, major components and anchorage shall be suitable for and certified to meet all applicable seismic requirements defined in Division 26 Section Vibration and Seismic Controls for Electrical Systems.

1.19 STATIC UNINTERRUPTABLE POWER SYSTEMS

A. Manufacturers

1. Liebert

2. Eaton Corp.

3. Toshiba

1.20 WIRING DEVICES

A. All receptacles shall be flushed and recessed in the wall or floor.

1.21 INTERIOR LIGHTING

A. All light fixtures shall be installed in areas accessible by ladder or lift to allow for ease of maintenance.

B. Standard fluorescent lamps shall be T8.

1.22 EXTERIOR LIGHTING

A. Provide fuses and fuse holders for outdoor lighting ballasts and light pole fixtures.

B. Outdoor flood lighting lamps shall be metal halide type.

C. Wallpacks shall be induction type.

1.23 APRON LIGHTING

A. Illuminance levels are as follows:

The minimum horizontal illuminance at ground level: 2.0 footcandles at a distance of 200 feet.

The maximum horizontal illuminance at ground level: 0.50 footcandles at a distance of 300 feet.

The minimum vertical illuminance at a height of 3 feet above ground level: 5.0 footcandles at a distance of 200 feet.

The maximum vertical illuminance at a distance of 250 feet: 0.25 footcandles at a height of 50 feet.

B. Floodlight fixture type shall be WideLite Aktra II and shall have an internal reflector to reduce glare and block high angle light.

C. Floodlight fixtures mounted on a lowering device shall have ballasts installed within the fixture. Fixtures mounted on non-lowering device poles shall have remotely located ballasts in a separate ballast enclosure, mounted to the lighting pole, at an accessible height.

D. Pole shafts shall be round tapered steel. Pole gauge for two-piece poles shall be minimum 3 gauge (0.2391") for lower section and minimum 7 gauge (0.1793") for upper section.

1.24 ELECTRICAL SUBMETERS

A. Electrical sub-meters are required to be installed for any tenant other than LAWA, in order to monitor electrical usage.

B. Sub-meter features shall include a display for cumulative kWh readings, kW demand loads, and built-in wireless transceiver.

C. Sub-meters shall be consolidated in multimeter enclosures in no more than 2 to 4 electrical rooms within the terminal.

D. The following loads shall be sub-metered with the most minimal amount of sub-meters: All Concessions separately, TSA rooms and equipment, In-Line Baggage system, passenger loading bridge power (including pre-conditioned air and 400Hz units), large electrical loads

such as major refrigeration units, Airline VIP lounges. The philosophy of sub-metering is to sub-meter any load type that is not common for all tenants, therefore not included in the general formula $$ /SQFT charged to tenants in addition of being exclusive to particular tenants.

1.25 APPROVED EQUIPMENT

A. All electrical equipment installed shall be listed by a City of Los Angeles recognized electrical testing laboratory.

END OF SECTION

# SECTION 26 05 02
# BASIC ELECTRICAL REQUIREMENTS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. This section supplements all sections of this Division and shall apply to all phases of work hereinafter specified, or required to provide a complete installation of electrical systems for the Project. The intent of the Specifications is to provide a complete electrical system that includes all documents that are a part of the Contract.

1. Work Included: Furnish all labor, material, services and skilled supervision necessary for the construction, erection, installation, connections, testing, and adjustment of all circuits and electrical equipment specified herein.

B. Equipment or Fixtures: Equipment and fixtures shall be connected to provide circuit continuity in accordance with the Specifications, whether or not each piece of conductor, conduit, or protective device is shown between such items of equipment or fixtures, and the point of circuit origin.

C. Work Installed but Furnished under Other Sections: The Electrical Work includes the installation or connection of certain materials and equipment furnished under other sections. Verify installation details. Foundations for apparatus and equipment will be furnished under other sections unless otherwise noted or detailed.

D. Provide conduit for all controls and other devices both line and low voltage. Install all control housings and back bone boxes required for installing conduit and wire to the controls.

E. Contractor to furnish a working system with all required connections for proper equipment operation. Information shown on drawings are diagrammatic in nature.

### 1.2 GENERAL REQUIREMENTS

A. Equipment Safety: All electrical materials and equipment shall be new and shall be listed by Underwriter's Laboratories and bear their label, or listed. Custom made equipment must have complete test data submitted by the manufacturer attesting to its safety.

B. Codes and Regulations:

1. Design, manufacture, testing and method of installation of all apparatus and materials furnished under the requirements of these specifications shall conform to the latest publications or standard rules of the following:

a. Institute of Electrical and Electronic Designers - IEEE

b. National Electrical Manufacturers' Association - NEMA

c. California Fire Code - CFC

d. California Building Code - CBC

e. Underwriters' Laboratories, Inc. - UL

f. National Fire Protection Association - NFPA

g. American Society for Testing and Materials - ASTM

h. American National Standards Institute - ANSI

i. American Standard Association - ASA

j. National Electrical Code - NEC, as modified by the city of Los Angeles

k. Insulated Power Cable Designers Association - IPCEA

l. California Code of Regulations, Title 24

m. International Electrical Testing Association - NETA

C. The term "Code", when used within the specifications. When a contradiction within the code occurs, most stringent code should take precedence.

D. Seismic Design of Electrical Equipment:

1. All electrical prefabricated equipment is to be designed and constructed in such a manner that all portions, elements, sub-assemblies and/or parts of said equipment and the equipment as a whole, including their attachments, will resist a horizontal load equal to the operating weights of those parts multiplied times the following factors:

| **TYPE OF EQUIPMENT** | **HORIZONTAL CP** | **VERTICAL CP** |
|---|---|---|
| Rigid and rigidly supported piping or equipment such as boilers, chillers, pumps, motors, transformers, unit substations and control panels. | 0.50 | 0.33 |
| Flexible and flexibly supported equipment such as air-handling units, piping and other equipment so supported that the fundamental period of vibration of the equipment and its supporting system is greater than 0.05 seconds. Communication equipment and emergency stand-by equipment | 1.00 | 0.6 |

2. Load is to be applied at the center of gravity of the part and to be in any direction horizontally.

3. Design stresses shall be in accordance with the specifications for design of the American Institute of Steel Construction. Anchorage, support and/or attachment of said prefabricated equipment to the structure should be in accordance with the details found in the plans and specifications.

4. Seismic restraints shall be designed for a 1.5 importance factor, and stamped structural calculations, signed by a California Registered Structural Engineer, will be provided as support.

5. It is the entire responsibility of the Contractor to verify the design of equipment so that the strength and anchorage of the internal components of the equipment exceeds the force level used to restrain and anchor the unit itself to the supporting structure.

6. If the state of California requires that certain electrical equipment and components have a special seismic certification, the contractor and vendor shall provide such certification.

E. Requirements of Regulatory Agencies:

1. Codes, Permits and Fees: Where the Contract Documents exceed minimum requirements, the Contract Documents take precedence. Where provisions differ in regard to code application, size, quality, quantity or type of equipment, Contractor shall include in the bid, costs for the most costly provision either denoted in the specifications or on the drawings. This provision shall apply as an amendment to the California Public Contracts Code.

a. Comply with all requirements for permits, licenses, fees and Code. Permits, licenses, fees, inspections and arrangements required for the Work shall be obtained by the Contractor at his expense, unless otherwise specified.

b. Comply with the requirements of the applicable utility companies serving the Project. Make all arrangements with the utility companies for proper coordination of the Work.

F. Shop Drawings and Submittals: Submittals on all material prior to installation.

1. Shop drawings shall be submitted on, but not limited to, the following:

2. Equipment Wiring Connections

3. Low Voltage Electrical Power Conductors and Cables

4. Grounding and Bonding for Electrical Systems

5. Hangers and Supports for Electrical Systems

6. Raceway and Boxes for Electrical Systems

7. Vibration and Seismic Controls for Electrical Systems

8. Identification for Electrical Systems

9. Lighting Control Devices

10. Low Voltage Transformers

11. Panelboards

12. Wiring Devices

13. Fuses

14. Enclosed Circuit Breakers

15. Interior Lighting

G. Cutting and Patching:

1. Obtain written permission from LAWA before core drilling or cutting any structural members. Exact method and location of conduit penetrations and/or openings in concrete walls, floors, or ceilings shall be as approved by LAWA.

2. Use care in piercing waterproofing. After the part piercing the waterproofing has been set in place, seal openings and make absolutely watertight.

3. Seal all openings to meet the fire rating of the particular wall floor or ceiling.

H. Miscellaneous:

1. LED control lights shall be used in all switchgear, switchboards, motor control centers and similar equipment.

2. Outdoor equipment enclosures shall be NEMA 4.

3. All floor-mounted equipment shall be installed on a concrete housekeeping pad. Refer to Hangers and Supports for Electrical Equipment (26 0530) Part 3.5 for requirements. (Added August 2013.)

I. Record Drawing:

1. General contractor shall submit record drawings using the latest AutoCad release at the time this contract is completed.

J. Contractor to coordinate work with other trades. Contractor to provide necessary coordination drawings as required.

1.3 JOB CONDITIONS

A. Existing Conditions:

1. The contractor shall visit the site and verify existing conditions.

2. Electrical circuits affecting work shall be de energized while working on or near them.

3. Arrange the work so that electrical power is available to all electrical equipment within existing facility at all times. Schedule all interruptions at the convenience of LAWA, including exact time and duration, in accordance with LAWA's power shut down procedures. Provide temporary power during all periods of interruption, which are deemed excessive by LAWA.

B. Protection:

1. Protection of apparatus, materials and equipment. Take such precautions as necessary to properly protect all apparatus, fixtures, appliances, material, equipment and installations from damage of any kind. LAWA may reject any particular piece or pieces of material, apparatus or equipment scratched, dented or otherwise damaged.

2. Seal equipment or components exposed to the weather and make watertight and insect proof. Protect equipment outlets and conduit openings with temporary plugs or caps at all times that work is not in progress.

3. Provide weather protection, with heaters, for equipment stored outdoors.

C. Sequencing and scheduling of any work shall be submitted to the reviewed and approved by LAWA.

1.4 POWER SHUTDOWN PROCEDURES

A. The contractor's construction schedule shall indicate dates of proposed electrical power shutdowns required to perform the installation. The contractor shall notify LAWA a minimum of thirty (30) days prior to each shutdown. All shutdown coordination meetings shall be arranged by the contractor for each shutdown.

B. Power shutdowns shall occur between the hours of 12:00 am and 4:00 am.

C. Only one switchboard shall be shutdown at any one time. Shutdowns shall be scheduled a minimum of three (3) days apart.

D. No interruptions to airport operations shall be allowed during periods deemed by LAWA as Holiday Construction Restriction Periods. These periods are typically from the Friday before the week of the Thanksgiving Holiday, to the following Monday after the Thanksgiving Holiday (9 calendar days) and the Friday before the week of the Christmas Holiday, to the Monday following New Year's Day (16 calendar days). Contractor shall verify the Holiday Construction Restriction Periods with LAWA prior to preparing the construction schedule.

E. Refer to the LAWA Utility Shutdown Procedures for additional information.

## 1.5 TESTING AND ADJUSTMENT

A. Upon completion of all Electrical Work, the contractor shall provide all testing as follows:

1. Operational Test: Test all circuit breakers, receptacles and all other electrical equipment. Replace all faulty devices and equipment discovered during testing with new devices and equipment at no additional cost, and that part of the system (or devices or equipment) shall then be retested.

2. Secondary Grounding Resistance: Perform ground continuity test between main ground system and equipment frame, system neutral and/or derived neutral point.

3. Ground Fault System Test: Measure system neutral insulation resistances to ensure no shunt ground paths exist.

4. All grounding resistance and ground fault test procedures shall be performed by an independent testing firm.

5. Submit all test results to LAWA.

## 1.6 MAINTENANCE, SERVICING AND INSTRUCTION MANUALS, AND WIRING DIAGRAMS

A. Prior to substantial completion, the contractor shall submit 4 copies of operating and maintenance and servicing instructions, as well as an equal number of copies of complete wiring diagrams all neatly bound in hard cover 3 ring binders with table of contents and tabs for the following items or equipment:

1. Lighting Control Devices System

2. Low Voltage Transformers

3. Panelboards

4. Wiring Devices

5. Fuses

6. Interior Lighting

B. All wiring diagrams shall specifically cover the installed system indicating zones, wiring, and components added to the system.

C. Include Product and calculations data with maintenance and Operations manuals. Include all testing reports with Maintenance and Operation manuals.

1.7 FINAL INSPECTION AND ACCEPTANCE

A. After all requirements of the specifications and/or the drawings have been fully completed, representatives of LAWA will inspect the Work. The Contractor shall provide competent personnel to demonstrate the operation of any item of system, to the full satisfaction of each representative. The Contractor shall provide 8 hours of minimum scheduled operation and maintenance training to staff to be trained on each system indicated above. See specific sections for additional training/operation hours required.

B. Provide manuals for attendees.

C. Final acceptance of the work will be made by LAWA after receipt of approval and recommendation of acceptance from each representative.

D. The Contractor shall furnish Record Drawings before final payment of retention.

1.8 WARRANTIES

A. Guarantee all materials, equipments, apparatus and workmanship to be free of defective material and faulty workmanship for period of one year unless extended guarantee periods are specified in individual sections.

B. During the period between Substantial Completion and Partial Acceptance (Final Acceptance of a defined area of the work), the Contractor shall provide the necessary services to Operate and Maintain the equipment in proper working order including, but not limited to:

1. Operation and Maintenance Response:

a. Provide twenty (24) hour emergency service during this period consisting of:

1) Critical Issue: A prompt response (within 15 minutes) to emergency request by telephone or otherwise from LAWA or designated representative. Onsite within 30 minutes of notification to triage and assess the situation.

2) Non Critical Issues: A prompt response (within 15 minutes) to request by telephone or otherwise from LAWA or designated representative. Onsite within one (1) hour after receiving notice from LAWA

representative or having knowledge of a need to service the system. If event occurs after business hours, weekends or holidays, response shall be within one (1) hour of commencement of next business day.

3) Scheduled Operational Needs: 24 hour notice of scheduled operational need. Failure to respond to scheduled operational need render need as a Critical Issue.

b. For Critical issues, on site response shall be within 30 minutes of notification. Repair or service of respective components and/or system shall be commenced immediately upon arrival on site. This requirement shall include after business hours, weekends, and holidays. Critical issues are defined as complete system failure, failure of controls, entrapments, and/or potential injury to persons, or other item that LAWA deems a critical operational need.

c. For Noncritical issues, on site response shall be within one (1) hour of notification. If event occurs after business hours, weekends, or holidays, response shall be within one (1) hour of commencement of next business day. Repair or service of respective components and/or system shall be commenced within (4) hours of the arrival on site.

2. Maintenance:

a. Inspection of completed installation and periodic testing to maintain equipment in completely operable, like new condition.

b. Perform any necessary regulatory testing to ensure system(s) are compliant with applicable code, all to the satisfaction of the Authority Having Jurisdiction.

c. Periodic lubrication of parts, filter changes and equipment components as per OEM's recommendation. Documentation to be provided for each piece of equipment when services are provided.

d. Spare Parts: The Contractor shall maintain adequate supply of spare parts during this period. Any spare parts utilized during this period that are part of the contractually obligated inventory of spare parts for Final Acceptance shall be replenished prior to Final Acceptance.

3. Operation:

a. All necessary work to operate/maintain the equipment in proper working order.

b. Perform daily maintenance and system health checks as applicable, and any necessary system backups, failover/failback testing.

c. Routinely monitoring equipment and systems for anomalies and respond or report to system maintenance team to respond and resolve.

d. Perform configuration changes as needed to support project, airport, tenant operations, etc.

e. Maintain logs of configuration changes.

4. Perform work without removing equipment from service during peak traffic periods (unless emergency and/or unless specifically authorized by LAWA) and those peak periods have been determined by LAWA as 7:00 a.m. to 12:00 a.m. (midnight) daily.

5. Unlimited regular time callbacks are included with the applicable response time. Regular time will be Monday through Friday, 8:00am to 4:30pm, exclusive of holidays. Overtime\Premium time call backs originating from an operational error related to the performance requirements of the equipment shall be borne by the Contractor.

END OF SECTION

# SECTION 26 05 03
# EQUIPMENT WIRING CONNECTIONS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes electrical connections to equipment.

B. Related Sections: Division 26 Series.

### 1.2 REFERENCES

A. National Electrical Manufacturers Association:

1. NEMA WD 1 - General Requirements for Wiring Devices.

2. NEMA WD 6 - Wiring Devices-Dimensional Requirements.

B. NFPA 70.

C. ANSI/IEE.

### 1.3 SUBMITTALS

A. Product Data: Submit wiring device manufacturer’s catalog information showing dimensions, configurations, and construction.

B. Manufacturer's installation instructions.

### 1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations, sizes, and configurations of equipment connections.

### 1.5 COORDINATION

A. Obtain and review shop drawings, product data, manufacturer’s wiring diagrams, and manufacturer's instructions for equipment furnished under other sections.

B. Determine connection locations and requirements.

C. Sequence rough-in of electrical connections to coordinate with installation of equipment.

D. Sequence electrical connections to coordinate with start-up of equipment.

## PART 2 - PRODUCTS

### 2.1 CORD AND PLUGS

A. Manufacturers:

1. Hubbell.

2. Leviton.

3. Pass and Seymour.

B. Attachment Plug Construction: Conform to NEMA WD 1.

C. Configuration: NEMA WD 6; match receptacle configuration at outlet furnished for equipment.

D. Specify cord type SJO for normal use and type SO for heavy duty use.

E. Cord Construction: Type SO or SJO multiconductor flexible cord with identified equipment grounding conductor, suitable for use in damp locations.

F. Size: Suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Verify equipment is ready for electrical connection, for wiring, and to be energized.

### 3.2 EXISTING WORK

A. Remove exposed abandoned equipment wiring connections, including abandoned connections above accessible ceiling finishes.

B. Disconnect abandoned utilization equipment and remove wiring connections. Remove abandoned components when connected raceway is abandoned and removed. Install blank cover for abandoned boxes and enclosures not removed.

C. Extend existing equipment connections using materials and methods compatible with existing electrical installations, or as specified.

## 3.3 INSTALLATION

A. Make electrical connections.

B. Make conduit connections to equipment using flexible conduit. Use liquidtight flexible conduit with watertight connectors in damp or wet locations.

C. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.

D. Install receptacle outlet to accommodate connection with attachment plug.

E. Install cord and cap for field-supplied attachment plug.

F. Install suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.

G. Install disconnect switches, controllers, control stations, and control devices to complete equipment wiring requirements.

H. Install terminal block jumpers to complete equipment wiring requirements.

I. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.

## 3.4 ADJUSTING

A. Cooperate with utilization equipment installers and field service personnel during checkout and starting of equipment to allow testing and balancing and other startup operations. Provide personnel to operate electrical system and checkout wiring connection components and configurations.

END OF SECTION

# SECTION 26 05 13
# MEDIUM-VOLTAGE CABLES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Medium voltage cable.
2. Cable terminations.
3. Fireproofing tape.
4. Underground cable markers.

### 1.2 REFERENCES

A. Institute of Electrical and Electronics Engineers

1. IEEE 48 – Standard Test Procedures and Requirements for Alternating Current Cable Terminations 2.5kV thru 765kV.
2. IEEE C2 – National Electrical Safety Code.

B. National Electrical Manufacturers Association

1. NEMA WC 74 – 5-46kV Shielded Power Cables for Use in the Transmission and Distribution of Electrical Energy.

### 1.3 SUBMITTALS

A. Product Data: Submit for cable, terminations, and accessories.

B. Test Reports: Indicate results of cable test in tabular form and in plots of current versus voltage for incremental voltage steps, and current versus time at 30 second intervals at maximum voltage.

## PART 2 - PRODUCTS

### 2.1 MEDIUM VOLTAGE CABLE

A. Manufacturers:

1. The Okonite Company.
2. General Cable.
3. Southwire.

B. Voltage: 5, 8, 15, and 35 kV.

C. Insulation Level: 133 percent of operating voltage.

D. Cable Continuous Operating Temperature Rating: MV-105.

E. Configuration: Single conductor.

F. Conductor Material: Copper.

G. Conductor Construction: Compact stranded.

H. Conductor Shield: Metal Tape.

I. Insulation: Ethylene Propylene Rubber (EPR).

J. Cable Jacket: Sunlight resistant PVC or Chlorosulfonated polyethylene, CPE.

## 2.2 CABLE TERMINATIONS

A. Manufacturers:

1. 3M.
2. Cooper.
3. Thomas & Betts.

B. Location: Indoor or Outdoor.

C. Conductor Quantity: Single core.

D. Type: Dual extrusion thick wall heat shrink.

## 2.3 FIREPROOFING TAPE

A. Manufacturers:

1. 3M.

2. Plymouth Rubber Company.

B. Product Description: Flexible, conformable fabric, coated on one side with flame retardant, flexible polymeric or chlorinated elastomer. Non-corrosive to and compatible with cable sheaths jackets. Does not support combustion.

C. Width: Approximately 3 inches.

D. Thickness: Not less than 0.03 inch.

E. Weight: Not less than 2.5 pounds per square yard.

## 2.4 UNDERGROUND CABLE MARKERS

A. Trace Wire: Magnetic detectable conductor, red colored plastic covering, imprinted with "Medium Voltage Cable" in large letters.

## 2.5 CABLE IDENTIFICATION

A. Colored Conductor Tape for Phases: Yellow colored, self-adhesive vinyl tape not less than 3 mils thick by 1 inch wide; 1 stripe for the Phase A conductor, 2 stripes for the Phase B conductor, 3 stripes for the Phase C conductor. Tape shall be located at all terminations, splices and pull boxes.

B. Metal Tags: Brass with ¼ inch embossed legend, punched for use with self-locking nylon tie fastener. Tags shall be located at all terminations, splices and pull boxes. Legend shall include the feeder circuit breaker identifier and phase.

# PART 3 - EXECUTION

## 3.1 PREPARATION

A. Use swab to clean conduits and ducts before pulling cables.

## 3.2 EXISTING WORK

A. Remove abandoned medium-voltage cable.

B. Maintain access to existing medium-voltage cable and other installations remaining active and requiring access. Modify installation or provide access panel.

## 3.3 INSTALLATION

A. Avoid abrasion and other damage to cables during installation.

B. Use suitable manufacturer approved lubricants and pulling equipment.

C. Sustain cable pulling tensions and bending radii below manufacturer's recommended limits.

D. Ground cable shield at each termination and splice.

E. Install cables in manholes along wall providing longest route.

F. Arrange cable in manholes to avoid interference with duct entrances.

3.4 FIREPROOFING

A. Apply fireproofing tape to cables when installed in manholes, cable rooms, pull boxes, or other enclosures.

B. Smooth out irregularities, at splices or other locations, with insulation putty before applying fireproofing tape.

C. Apply fireproofing tape tightly around cables spirally in half-lapped wrapping or in butt jointed wrapping with second wrapping covering joints first.

D. Extend fireproofing 1 inch into conduit or duct.

E. Install tape with coated side toward cable.

F. Install random wrappings of plastic tape around fireproofing tape to prevent unraveling.

G. Install fireproofing to withstand a 200 Ampere arc for 30 seconds.

3.5 FIELD QUALITY CONTROL

A. Inspect exposed cable sections for physical damage.

B. Inspect cable for proper connections.

C. Inspect shield grounding, cable supports, and terminations for proper installation.

D. Inspect and test in accordance with NETA ATS.

3.6 PROTECTION OF INSTALLED CONSTRUCTION

A. Protect installed cables from entrance of moisture.

END OF SECTION

# SECTION 26 05 16
# EMERGENCY CIRCUIT CONDUCTORS AND CABLES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. This Section includes building wires and cables and associated connectors, splices and terminations for emergency or critical circuits rated 600 V and less.

B. Related Sections: Division 26 Series.

### 1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

### 1.3 QUALITY ASSURANCE

A. 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.

B. Comply with NFPA 70.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

A. CONDUCTORS AND CABLES

1. Manufacturers:

a. Draka USA

b. AEI Cables.

c. Pyrotenax.

B. CONDUCTORS SPLICES

1. 3M Company-Interam E-5 Series Mat with Metal Pull Boxes.

2. O-Z/Gedny; EGS Electrical Products Division.

3. Factory-fabricated connectors and splices of size, ampacity rating, material, type and class for application required.

## PART 3 - EXECUTION

### 3.1 CONDUCTOR AND INSULATION APPLICATIONS

A. Fire Pump and Emergency Smoke Control System Conductors: 600V RHH Power Cable

1. Cables must be Ul Classified Circuit Protective System with a 2-Hour fire rating when installed in the conduit.

2. Conduit supports shall be spaced no further than every 5' on center.

3. The cable shall utilize silicone ceramification technology in order to maintain circuit integrity.

4. Cables shall be tested to Ul Standard 2196 - Fire Resistive Cables.

5. Cables shall comply with Ul Subject #44 for Rubber Insulated Type RHH.

6. Cables shall meet the requirements of Article 700 of the NEC-Emergency Systems.

7. Cables shall comply to the International Building Code and "protect against exposure to temperatures in excess of 10000 F (5380 C) for a period of not less than 15 minutes.

### 3.2 INSTALLATION

A. Run smoke control system evacuation cable/conduit in accordance with applicable sections of these specifications. Install fire pump conduits.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and side wall pressure valves.

C. Use pulling means, including fish tape, cable rope and basket-weave wire/cable grips, that will not damage cable of raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to the applicable UL Listing for each product type being installed.

F. Seal around cables penetrating fire-rated elements.

G. Identify and color-code conductors and cables.

H. Comply with UL electrical circuit protective system FHIT #25.

3.3 CONNECTIONS

A. 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 and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

3.4 FIELD QUALITY CONTROL

A. Testing: Perform the following field-quality control testing:

1. After installing conductors and cables and before electrical circuitry has been energized, test for compliance and requirements.

2. Perform electrical and visual and mechanical inspection. Certify compliance with test parameters.

B. Test Reports: Prepare a written report to record the following:

1. Test procedures used.

2. Test results that comply with the construction documents.

3. Test results that do not comply with the construction documents and corrective action taken to achieve contract compliance.

END OF SECTION

# SECTION 26 05 19
# LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. This section pertains to 600v class power conductors and cabling.

B. Section includes building wire and cable; service entrance cable; armored cable; and wiring connectors and connections.

### 1.2 REFERENCES

A. International Electrical Testing Association:

1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

B. National Fire Protection Association:

1. NFPA 70 - National Electrical Code.

2. NFPA 262 - Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

C. Underwriters Laboratories, Inc.:

1. UL 1277 - Standard for Safety for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.

D. Related Sections: Division 26 Series.

### 1.3 SYSTEM DESCRIPTION

A. Product Requirements: Provide products as follows:

1. Solid conductor for feeders and branch circuits 12 AWG and smaller

2. Stranded conductors for control circuits.

3. Conductor not smaller than 12 AWG for power and lighting circuits.

4. Conductor not smaller than 14 AWG for control circuits.

5. Increase wire size in branch circuits to limit voltage drop to a maximum of 3 percent.

B. Wiring Methods: Provide the following wiring methods:

1. Concealed Dry Interior Locations: Use only building wire, Type THHN/THWN insulation, in raceway.

2. Exposed Dry Interior Locations: Use only building wire, Type THHN/THWN insulation, in raceway.

3. Above Accessible Ceilings: Use only building wire, Type THHN/THWN insulation, in raceway.

4. Wet or Damp Interior Locations: Use only building wire, Type THHN/THWN insulation, in raceway.

5. Exterior Locations: Use only building wire, Type THHN/THWN insulation, in raceway.

6. Underground Locations: Use only building wire, Type THHN/THWN or XHHW2 insulation, in raceway.

7. Other Locations: Use only building wire, Type THHN/THWN insulation, in raceway.

8. Metal clad cables shall not be used.

C. Develop a written plan of procedures for testing and adjusting new systems.

D. Contractor to provide shop drawing prior to procurement.

1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of components and circuits.

B. Include a copy of all inspection verifications and reports required by the Department.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing

PART 2 - PRODUCTS

2.1 BUILDING WIRE

A. Manufacturers:

1. General Cable Co.

2. Southwire Co.

3. The Okonite Company.

B. Product Description: Single conductor insulated wire.

C. Conductor: Copper.

D. Insulation Voltage Rating: 600 volts.

E. Insulation Temperature Rating: 75 degrees C.

F. Insulation Material: Thermoplastic.

2.2 ARMONED CABLE

A. Manufacturers:

1. General Cable.

2. Southwire Co.

3. The Okonite Company.

2.3 TERMINATIONS

A. Terminal Lugs for Wires 6 AWG and Smaller: Solderless, compression type copper.

B. Lugs for Wires 4 AWG and Larger: Color keyed, compression type copper, with insulating sealing collars.

PART 3 - EXECUTION

3.1 PREPARATION

A. Completely and thoroughly swab raceway before installing wire.

3.2 INSTALLATION

A. Neatly train and lace wiring inside boxes, equipment, and panelboards.

B. Identify and color code wire and cable as described herein. Identify each conductor with its circuit number or other designation indicated.

C. Special Techniques--Building Wire in Raceway:

1. Pull conductors into raceway at same time.

2. Install building wire 4 AWG and larger with pulling equipment.

D. Special Techniques - Cable:

1. Protect exposed cable from damage.

2. Support cables above accessible ceiling, using spring metal clips or metal plastic cable ties to support cables from structure or ceiling suspension system. Do not rest cable on ceiling panels.

E. Special Techniques - Wiring Connections:

1. Clean conductor surfaces before installing lugs and connectors.

2. Make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.

3. Tape uninsulated conductors and connectors with electrical tape to 150 percent of insulation rating of conductor.

4. Install split bolt connectors for copper conductor splices and taps, 6 AWG and larger.

5. Install solderless pressure connectors with insulating covers for copper conductor splices and taps, 8 AWG and smaller.

6. Install insulated spring wire connectors with plastic caps for copper conductor splices and taps, 10 AWG and smaller.

F. Install solid conductors for branch circuits 10 AWG and smaller. Do not place bare stranded conductors directly under screws.

G. Install terminal lugs on ends of 600 volt wires unless lugs are furnished on connected device, such as circuit breakers.

H. Size lugs in accordance with manufacturer's recommendations terminating wire sizes. Install 2-hole type lugs to connect wires 4 AWG and larger to copper bus bars.

I. For terminal lugs fastened together such as on motors, transformers, and other apparatus, or when space between studs is small enough that lugs can turn and touch each other, insulate for dielectric strength of 2-1/2 times normal potential of circuit.

## 3.3 WIRE COLOR

A. General:

1. For wire sizes 12 AWG and smaller, install wire colors in accordance with the following:

a. Black and red for single phase circuits at 120/240 volts.

b. Black, red, and blue for circuits at 120/208 volts single or three phase.

c. Orange, brown, and yellow for circuits at 277/480 volts single or three phase.

2. For all wire sizes, identify wire with colored tape at terminals, splices and boxes. Colors are as follows:

a. Black and red for single phase circuits at 120/240 volts.

b. Black, red, and blue for circuits at 120/208 volts single or three phase.

c. Orange, brown, and yellow for circuits at 277/480 volts single or three phase.

B. Neutral Conductors: White. When two or more neutrals are located in one conduit, individually identify each with proper circuit number.

C. Branch Circuit Conductors: Install three or four wire home runs with each phase uniquely color coded.

D. Feeder Circuit Conductors: Uniquely color code each phase.

E. Ground Conductors:

1. For all wire sizes: Green.

2. For 4 AWG and larger: Identify with green tape at both ends and visible points including junction boxes.

## 3.4 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Perform inspections and tests listed in NETA ATS, Section 7.3.1.

## 3.5 TESTING AND ADJUSTMENT

A. Testing and adjusting of systems shall be required for any new system.

B. Perform testing and adjusting procedures in accordance with industry best practices and applicable standards on each system as determined by the Building Official.

## 3.6 MAINTENANCE

A. Provide the building owner or representative with detailed operating and maintenance instructions and copies of guarantees/warranties for each new system. Operating and

maintenance instruction shall be consistent with OSHA requirements in CCR, Title 8, Section 5142, and other related regulations.

3.7 FINAL INSPECTION

A. Include a copy of all inspection verifications and reports required by the Department.

END OF SECTION

# SECTION 26 05 27
# GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Rod electrodes.
2. Wire.
3. Grounding well components.
4. Mechanical connectors.
5. Exothermic connections.

### 1.2 REFERENCES

A. Institute of Electrical and Electronics Designers:

1. IEEE 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.
2. IEEE 1100 - Recommended Practice for Powering and Grounding Electronic Equipment.

B. International Electrical Testing Association:

1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

C. National Fire Protection Association:

1. NFPA 70 - National Electrical Code.

### 1.3 SYSTEM DESCRIPTION

A. Grounding systems use the following elements as grounding electrodes:

1. Metal underground water pipe.
2. Metal building frame.

3. Concrete-encased electrode.

4. Rod electrode.

5. Plate electrode.

1.4 PERFORMANCE REQUIREMENTS

A. Grounding System Resistance: 5 ohms maximum.

1.5 SUBMITTALS

A. Product Data: Submit data on grounding electrodes and connections.

B. Test Reports: Indicate overall resistance to ground and resistance of each electrode.

C. Manufacturer's Installation Instructions: Submit for active electrodes.

D. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.6 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of components and grounding electrodes.

1.7 QUALITY ASSURANCE

A. Maintain one copy of each document on site.

1.8 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.

B. Installer: Company specializing in performing work of this section with minimum 5 years documented experience and approved by manufacturer.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in original factory packaging, labeled with manufacturer's identification.

B. Protect from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original packaging.

C. Do not deliver items to project before time of installation. Limit shipment of bulk and multiple-use materials to quantities needed for immediate installation.

1.10 COORDINATION

A. Complete grounding and bonding of building reinforcing steel prior concrete placement.

PART 2 - PRODUCTS

2.1 ROD ELECTRODES

A. Manufacturers:

1. Erico, Inc.

2. O-Z Gedney Co.

3. Thomas & Betts.

B. Product Description:

1. Material: Copper-clad steel.

2. Diameter: 3/4 inch

3. Length: 10 feet

C. Connector: Connector for exothermic welded connection.

2.2 WIRE

A. Material: Stranded copper.

B. Foundation Electrodes: 4/0 AWG, unless otherwise noted.

C. Grounding Electrode Conductor: Copper conductor bare.

D. Bonding Conductor: Copper conductor bare.

2.3 GROUNDING WELL COMPONENTS

A. Well Pipe: 8 inches NPS (DN200) by 24 inches long fiberglass pipe with belled end.

B. Well Cover: Cast iron with legend "GROUND" embossed on cover.

2.4 MECHANICAL CONNECTORS

A. Manufacturers:

1. Erico, Inc.

2. ILSCO Corporation

3. O-Z Gedney Co.

B. Description: Bronze connectors, suitable for grounding and bonding applications, in configurations required for particular installation.

2.5 EXOTHERMIC CONNECTIONS

A. Manufacturers:

1. Copperweld, Inc.

2. ILSCO Corporation

3. O-Z Gedney Co.

B. Product Description: Exothermic materials, accessories, and tools for preparing and making permanent field connections between grounding system components.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify final backfill and compaction has been completed before driving rod electrodes.

3.2 PREPARATION

A. Remove paint, rust, mill oils and surface contaminants at connection points.

3.3 INSTALLATION

A. Install rod electrodes as required. Install additional rod electrodes to achieve specified resistance to ground.

B. Install grounding and bonding conductors concealed from view.

C. Install grounding well pipe with cover at each rod location. Install well pipe top flush with finished grade.

D. Install 4/0 AWG bare copper wire in foundation footing.

E. Install grounding electrode conductor and connect to reinforcing steel in foundation footing.

F. Bond together metal siding not attached to grounded structure; bond to ground.

G. Equipment Grounding Conductor: Install separate, insulated conductor within each feeder and branch circuit raceway. Terminate each end on suitable lug, bus, or bushing.

H. Install continuous grounding using underground cold water system and building steel as grounding electrode. Where water piping is not available, install artificial station ground by means of driven rods or buried electrodes.

I. Permanently ground entire light and power system in accordance with NEC, including service equipment, distribution panels, lighting panelboards, switch and starter enclosures, motor frames, grounding type receptacles, and other exposed non-current carrying metal parts of electrical equipment.

J. Install from grounding bus of serving panel to ground bus of served panel, grounding screw of receptacles, lighting fixture housing, light switch outlet boxes or metal enclosures of service equipment. Ground conduits by means of grounding bushings on terminations at panelboards with installed number 12 conductor to grounding bus.

K. Permanently attach equipment and grounding conductors prior to energizing equipment.

L. The Uffer ground grounding electrode shall consist of a 50-foot length of bare #4/0 copper wire extended its full length below ground level and embedded along the bottom of the concrete foundation footing which is in direct contact with the foundation earth and supported in such a manner that it cannot be less than 3 inches from the bottom or side of the concrete when the foundation concrete is poured. A loop at the approximate center of this grounding electrode shall be brought out at the top of the foundation and a #4/0 copper ground conductor shall connect the ground electrode to the main ground electrode bus in the equipment room. The conductor shall be connected to the ground electrode by exothermic welding.

## 3.4 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Grounding and Bonding: Perform inspections and tests listed in NETA ATS, Section 7.13.

C. Perform ground resistance testing in accordance with IEEE 142.

D. Perform leakage current tests in accordance with NFPA 99.

E. Perform continuity testing in accordance with IEEE 142.

F. When improper grounding is found on receptacles, check receptacles in entire project and correct.

G. Perform retest.

END OF SECTION

# SECTION 26 05 30
# HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Conduit supports.
2. Formed steel channel.
3. Spring steel clips.
4. Sleeves.
5. Mechanical sleeve seals.
6. Firestopping relating to electrical work.
7. Firestopping accessories.
8. Equipment bases and supports.

### 1.2 REFERENCES

A. ASTM International:

1. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
2. ASTM E119 - Standard Test Methods for Fire Tests of Building Construction and Materials.
3. ASTM E814 - Standard Test Method for Fire Tests of Through-Penetration Fire Stops.
4. ASTM E1966 - Standard Test Method for Fire-Resistive Joint Systems.

B. FM Global:

1. FM - Approval Guide, A Guide to Equipment, Materials and Services Approved By Factory Mutual Research For Property Conservation.

C. National Fire Protection Association:

1. NFPA 70 - National Electrical Code.

D. Underwriters Laboratories Inc.:

1. UL 263 - Fire Tests of Building Construction and Materials.

2. UL 723 - Tests for Surface Burning Characteristics of Building Materials.

3. UL 1479 - Fire Tests of Through-Penetration Firestops.

4. UL 2079 - Tests for Fire Resistance of Building Joint Systems.

5. UL - Fire Resistance Directory.

E. Intertek Testing Services (Warnock Hersey Listed):

1. WH - Certification Listings.

1.3 DEFINITIONS

A. Firestopping (Through-Penetration Protection System): Sealing or stuffing material or assembly placed in spaces between and penetrations through building materials to arrest

1.4 SYSTEM DESCRIPTION

A. Firestopping Materials: Achieve fire ratings for adjacent construction, but not less than 1 hour fire rating.

1.5 PERFORMANCE REQUIREMENTS

A. Firestopping: Conform to applicable code FM, UL, and WH for fire resistance ratings and surface burning characteristics.

B. Firestopping: Provide certificate of compliance from authority having jurisdiction indicating approval of materials used.

C Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

D Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

E Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

F Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.6 SUBMITTALS

A. Shop Drawings: Indicate system layout with location and detail of trapeze hangers.

B. Product Data:

1. Hangers and Supports: Submit manufacturers catalog data including load capacity.

2. Firestopping: Submit data on product characteristics, performance and limitation criteria.

C. Firestopping Schedule: Submit schedule of opening locations and sizes, penetrating items, and required listed design numbers to seal openings to maintain fire resistance rating of adjacent assembly.

D. Design Data: Indicate load carrying capacity of trapeze hangers and hangers and supports.

E. Manufacturer's Installation Instructions:

1. Hangers and Supports: Submit special procedures and assembly of components.

2. Firestopping: Submit preparation and installation instructions.

F. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.7 QUALITY ASSURANCE

A. Through Penetration Firestopping of Fire Rated Assemblies: UL 1479 or ASTM E814 with 0.10 inch water gage (24.9 Pa) minimum positive pressure differential to achieve fire F-Ratings and temperature T-Ratings, but not less than 1-hour.

1. Wall Penetrations: Fire F-Ratings, but not less than 1-hour.

2. Floor and roof penetrations: Fire F-Ratings and temperature T-Ratings, but not less than 1-hour.

a. Floor Penetrations Within Wall Cavities: T-Rating is not required.

B. Through Penetration Firestopping of Non-Fire Rated Floor and Roof Assemblies: Materials to resist free passage of flame and products of combustion.

1. Non-combustible Penetrating Items: Non-combustible materials for penetrating items connecting maximum of three stories.

2. Penetrating Items: Materials approved by authorities having jurisdiction for penetrating items connecting maximum of two stories.

C. Fire Resistant Joints in Fire Rated Floor, Roof, and Wall Assemblies: ASTM E1966 or UL 2079 to achieve fire resistant rating for assembly in which joint is installed.

D. Fire Resistant Joints Between Floor Slabs and Exterior Walls: ASTM E119 with 0.10 inch water gage (24.9 Pa) minimum positive pressure differential to achieve fire resistant rating for floor assembly.

E. Surface Burning Characteristics: 25/450 flame spread/smoke developed index when tested in accordance with ASTM E84.

F. Maintain one copy of each document on site.

G. Comply with CBC Seismic and Gravity Design Criteria.

1.8 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.

B. Installer: Company specializing in performing work of this section with minimum 5years documented experience and approved by manufacturer.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in original factory packaging, labeled with manufacturer's identification.

B. Protect from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original packaging.

1.10 ENVIRONMENTAL REQUIREMENTS

A. Do not apply firestopping materials when temperature of substrate material and ambient air is below 60 degrees F (15 degrees C).

B. Maintain this minimum temperature before, during, and for minimum 3 days after installation of firestopping materials.

PART 2 - PRODUCTS

## 2.1 CONDUIT SUPPORTS

A. Manufacturers:

1. Allied Tube and Conduit Corp.

2. Powerstrut.

3. Unistrut.

B. Hanger Rods: Threaded high tensile strength galvanized carbon steel with free running threads.

C. Beam Clamps: Malleable Iron, with tapered hole in base and back to accept either bolt or hanger rod. Set screw: hardened steel.

D. Conduit clamps for trapeze hangers: Galvanized steel, notched to fit trapeze with single bolt to tighten.

E. Conduit clamps - general purpose: One hole malleable iron for surface mounted conduits.

F. Cable Ties: High strength nylon temperature rated to 185 degrees F (85 degrees C). Self-locking.

## 2.2 FORMED STEEL CHANNEL

A. Manufacturers:

1. Allied Tube and Conduit Corp.

2. Unistrut Corp.

3. Powerstrut.

B. Product Description: Galvanized 12 gage thick steel. With holes 1-1/2 inches on center.

## 2.3 SLEEVES

A. Furnish materials in accordance with standards.

B. Sleeves for conduits through Non-fire Rated Floors: 18 gage (1.2 mm) thick galvanized steel.

C. Sleeves for conduits through Non-fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Steel pipe or 18gage thick galvanized steel.

D. Sleeves for conduits through Fire Rated and Fire Resistive Floors and Walls, and Fire Proofing:

1. Prefabricated fire rated sleeves including seals, UL listed.

E. Fire-stopping Insulation: Glass fiber type, non-combustible.

## 2.4 MECHANICAL SLEEVE SEALS

A. Manufacturers:

1. Thunderline Link-Seal, Inc.

2. NMP Corporation.

B. Product Description: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between object and sleeve, connected with bolts and pressure plates causing rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.

## 2.5 FIRESTOPPING

A. Manufacturers:

1. Dow Corning Corporation

2. Hilti Corporation

3. 3M Fire Protection Products

B. Product Description: Different types of products by multiple manufacturers are acceptable as required to meet specified system description and performance requirements; provide only one type for each similar application.

1. Silicone Firestopping Elastomeric Firestopping: Multiple component silicone elastomeric compound and compatible silicone sealant.

2. Foam Firestopping Compounds: Multiple component foam compound.

3. Formulated Firestopping Compound of Incombustible Fibers: Formulated compound mixed with incombustible non-asbestos fibers.

4. Fiber Stuffing and Sealant Firestopping: Composite of mineral fiber stuffing insulation with silicone elastomer for smoke stopping.

5. Mechanical Firestopping Device with Fillers: Mechanical device with incombustible fillers and silicone elastomer, covered with sheet stainless steel jacket, joined with collars, penetration sealed with flanged stops.

6. Intumescent Firestopping: Intumescent putty compound which expands on exposure to surface heat gain.

7. Firestop Pillows: Formed mineral fiber pillows.

C. Color: Dark gray

2.6 FIRESTOPPING ACCESSORIES

A. Primer: Type recommended by firestopping manufacturer for specific substrate surfaces and suitable for required fire ratings.

B. Dam Material: Permanent:

1. Mineral fiberboard.

2. Mineral fiber matting.

3. Sheet metal.

C. Installation Accessories: Provide clips, collars, fasteners, temporary stops or dams, and other devices required to position and retain materials in place.

D. General:

1. Furnish UL listed products or products tested by independent testing laboratory.

2. Select products with rating not less than rating of wall or floor being penetrated.

E. Non-Rated Surfaces:

1. Stamped steel, chrome plated, hinged, split ring escutcheons or floor plates or ceiling plates for covering openings in occupied areas where conduit is exposed.

2. For exterior wall openings below grade, furnish modular mechanical type seal consisting of interlocking synthetic rubber links shaped to continuously fill annular space between conduit and cored opening or water-stop type wall sleeve.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify openings are ready to receive sleeves.

B. Verify openings are ready to receive firestopping.

3.2 PREPARATION

A. Clean substrate surfaces of dirt, dust, grease, oil, loose material, or other matter affecting bond of firestopping material.

B. Remove incompatible materials affecting bond.

C. Install backing materials to arrest liquid material leakage.

D. Obtain permission from Designer before using powder-actuated anchors.

E. Do not drill or cut structural members.

F. Obtain permission from Designer before drilling or cutting structural members.

3.3 INSTALLATION - HANGERS AND SUPPORTS

A. Anchors and Fasteners:

1. Concrete Structural Elements: Provide precast inserts systems, expansion anchors, powder actuated anchors and preset inserts.

2. Steel Structural Elements: Provide beam clamps with spring steel clips, steel ramset fasteners, and welded fasteners.

3. Concrete Surfaces: Provide self-drilling anchors and expansion anchors.

4. Hollow Masonry, Plaster, and Gypsum Board Partitions: Provide toggle bolts and hollow wall fasteners.

5. Solid Masonry Walls: Provide expansion anchors and preset inserts.

6. Sheet Metal: Provide sheet metal screws.

7. Wood Elements: Provide wood screws.

B. Inserts:

1. Install inserts for placement in concrete forms.

2. Install inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.

4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut flush with top of slab.

C. Install conduit and raceway support and spacing in accordance with NEC.

D. Do not fasten supports to pipes, ducts, mechanical equipment, or conduit.

E. Install multiple conduit runs on common hangers.

F. Supports:

1. Fabricate supports from structural steel or formed steel channel. Install hexagon head bolts to present neat appearance with adequate strength and rigidity. Install spring lock washers under nuts.

2. Install surface mounted cabinets and panelboards with minimum of four anchors.

3. In wet and damp locations install steel channel supports to stand cabinets and panelboards 1 inch off wall.

4. Support vertical conduit at every floor.

## 3.4 INSTALLATION – FIRESTOPPING

A. Install material at fire rated construction perimeters and openings containing penetrating sleeves, piping, ductwork, conduit and other items, requiring firestopping.

B. Apply primer where recommended by manufacturer for type of firestopping material and substrate involved, and as required for compliance with required fire ratings.

C. Apply firestopping material in sufficient thickness to achieve required fire and smoke rating, to uniform density and texture.

D. Compress fibered material to maximum 40 percent of its uncompressed size.

E. Place foamed material in layers to ensure homogenous density, filling cavities and spaces. Place sealant to completely seal junctions with adjacent dissimilar materials.

F. Place intumescent coating in sufficient coats to achieve rating required.

G. Remove dam material after firestopping material has cured. Dam material to remain.

H. Fire Rated Surface:

1. Seal opening at floor, wall, partition, ceiling, and roof as follows:

a. Install sleeve through opening and extending beyond minimum of 1 inch (25 mm) on both sides of building element.

b. Size sleeve allowing minimum of 1 inch (25 mm) void between sleeve and building element.

c. Pack void with backing material.

d. Seal ends of sleeve with UL listed fire resistive silicone compound to meet fire rating of structure penetrated.

2. Where cable tray and conduits penetrate fire rated surface, install firestopping product in accordance with manufacturer's instructions.

a. Non-Rated Surfaces:

3. Seal opening through non-fire rated wall, floor, ceiling, and roof opening as follows:

a. Install sleeve through opening and extending beyond minimum of 1 inch (25 mm) on both sides of building element.

b. Size sleeve allowing minimum of 1 inch (25 mm) void between sleeve and building element.

c. Install type of firestopping material recommended by manufacturer.

4. Install escutcheons floor plates or ceiling plates where conduit, penetrates non-fire rated surfaces in occupied spaces. Occupied spaces include rooms with finished ceilings and where penetration occurs below finished ceiling.

5. Exterior wall openings below grade: Assemble rubber links of mechanical seal to size of conduit and tighten in place, in accordance with manufacturer's instructions.

## 3.5 INSTALLATION - EQUIPMENT BASES AND SUPPORTS

A. Construct concrete housekeeping pads, minimum 4 inches above the finished floor and not less than 4 inches larger in both direction than the supported equipment. Use 3000 psi, 28-day compressive-strength concrete. Pads shall be reinforced with #4 steel reinforcing rods.

B. Using templates furnished with equipment, install anchor bolts, and accessories for mounting and anchoring equipment.

C. Construct supports of steel members or formed steel channel. Brace and fasten with flanges bolted to structure.

3.6 INSTALLATION - SLEEVES

A. Exterior watertight entries: Seal with adjustable interlocking rubber links.

B. Conduit penetrations not required to be watertight: Sleeve and fill with silicon foam.

C. Set sleeves in position in forms. Provide reinforcing around sleeves.

D. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.

E. Extend sleeves through floors 1inch above finished floor level. Caulk sleeves.

F. Where conduit or raceway penetrates floor, ceiling, or wall, close off space between conduit or raceway and adjacent work with fire stopping insulation and caulk. Provide close fitting metal collar or escutcheon covers at both sides of penetration.

G. Install stainless steel escutcheons at finished surfaces.

3.7 FIELD QUALITY CONTROL

A. Inspect installed firestopping for compliance with specifications and submitted schedule.

3.8 CLEANING

A. Clean adjacent surfaces of firestopping materials.

3.9 PROTECTION OF FINISHED WORK

A. Protect adjacent surfaces from damage by material installation.

END OF SECTION

# SECTION 26 05 33
# RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes conduit and tubing, surface raceways, wireways, outlet boxes, pull and junction boxes, and handholes.

B. Related Sections: Division 26 Series.

### 1.2 REFERENCES

A. American National Standards Institute:

1. ANSI C80.1 - Rigid Steel Conduit, Zinc Coated.

2. ANSI C80.3 - Specification for Electrical Metallic Tubing, Zinc Coated.

B. National Electrical Manufacturers Association:

1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

2. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies.

3. NEMA OS 1 - Sheet Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.

4. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.

5. NEMA TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing.

### 1.3 SYSTEM DESCRIPTION

A. Raceway and boxes at locations required for splices, taps, wire pulling, equipment connections, and compliance with regulatory requirements. Raceway and boxes are shown in approximate locations unless dimensioned. Provide raceway to complete wiring system.

B. Wet and Damp Locations: Provide rigid galvanized steel conduit. Provide cast metal or nonmetallic outlet, junction, and pull boxes. Provide flush mounting outlet box in finished areas.

C. Exposed Dry Locations: Provide rigid galvanized steel conduit. Electrical metallic tubing may be used 10’ above finished grade. Provide sheet-metal boxes. Provide flush mounting outlet box in finished areas. Provide hinged enclosure for large pull boxes.

D. Concealed Dry Locations: Provide electrical metallic tubing. Provide sheet-metal boxes. Provide flush mounting outlet box in finished areas. Provide hinged enclosure for large pull boxes.

E. EMT conduit is restricted to interior dry location not subject to possible physical damage. PVC conduit is restricted to underground use and shall be concrete encased.

F. In or Under Slab, On Grade: Provide rigid steel conduit, plastic coated conduit or thickwall non-metallic conduit. Provide cast metal or non-metallic boxes.

G. In Slab Above Grade: Provide rigid steel conduit, electrical metallic tubing or thickwall non-metallic conduit. Provide cast metal or non-metallic boxes.

H. Wet Locations, Above Grade: Provide rigid galvanized steel conduit. Provide cast metal or nonmetallic outlet, pull, and junction boxes. Provide flush mounting outlet box in finished areas.

I. Damp Locations: Provide rigid galvanized steel conduit. Provide cast metal or nonmetallic outlet, junction, and pull boxes. Provide flush mounting outlet box in finished areas. These locations include, but are not limited to, areas underneath buildings open to the outdoor environment.

J. Dry Locations, Exposed and Concealed: Provide electrical metallic tubing conduit. Rigid galvanized steel conduit shall be used in areas subject to physical damage. Provide sheet- metal boxes. Provide flush mounting outlet box in finished areas.

K. PVC conduit is restricted to underground use and shall be concrete encased.

## 1.4 DESIGN REQUIREMENTS

A. Minimum Raceway Size: 3/4 inch unless otherwise specified.

## 1.5 SUBMITTALS

A. Product Data - Submit for the following:

1. Flexible metal conduit.
2. Liquid tight flexible metal conduit.
3. Non-metallic conduit.
4. Raceway fittings.
5. Conduit bodies.
6. Surface raceway.
7. Wireway.

8. Pull and junction boxes.

B. Manufacturer's Installation Instructions: Submit application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.

## PART 2 - PRODUCTS

### 2.1 METAL CONDUIT

A. Manufacturers:

1. Allied Tube and Conduit Corporation.

2. Republic Conduit.

3. Wheatland Tube.

B. Rigid Steel Conduit: ANSI C80.1.

C. Intermediate Metal Conduit (IMC): Rigid steel.

D. Fittings and Conduit Bodies: NEMA FB 1; material to match conduit.

1. Manufacturers:

a. Cooper Crouse-Hinds.

b. O-Z/Gedney.

c. Thomas & Betts.

### 2.2 PVC COATED METAL CONDUIT

A. Manufacturers:

1. Ocal-Blue.

2. Permacote.

3. Plastibond.

B. Product Description: NEMA RN 1; rigid steel conduit with external PVC coating, 40 mil thick.

C. Fittings and Conduit Bodies: NEMA FB 1; steel fittings with external PVC coating to match conduit.

2.3 FLEXIBLE METAL CONDUIT

A. Manufacturers:

1. AFC Cable.
2. Electri-Flex.
3. Southwire Co.

B. Product Description: Interlocked steel construction.

C. Fittings: NEMA FB 1.

1. AFC Cable.
2. Cooper Crouse-Hinds.
3. Thomas and Betts.

2.4 LIQUIDTIGHT FLEXIBLE METAL CONDUIT

A. Manufacturers:

1. AFC Cable.
2. Electri-Flex.
3. Southwire Co.

B. Product Description: Interlocked steel construction with PVC jacket.

C. Fittings: NEMA FB 1.

1. AFC Cable.
2. Cooper Crouse-Hinds.
3. Thomas and Betts.

2.5 ELECTRICAL METALLIC TUBING (EMT)

A. Manufacturers:

1. Allied Tube Corp.
2. Republic Conduit

3. Wheatland Tube.

B. Product Description: ANSI C80.3; galvanized tubing.

C. Fittings and Conduit Bodies: NEMA FB 1; steel or malleable iron, compression type.

1. Manufacturers:

a. Cooper Crouse-Hinds.

b. O-Z/Gedney.

c. Thomas and Betts.

## 2.6 NON-METALLIC CONDUIT

A. Manufacturers:

1. Allied Tube & Conduit.

2. Cantex.

3. JW Eagle.

B. Product Description: NEMA TC 2; Schedule 40 or 80 PVC.

C. Fittings and Conduit Bodies: NEMA TC 3.

## 2.7 SURFACE METAL RACEWAY

A. Manufacturers:

1. Walker Systems Inc.

2. The Wiremold Co.

B. Product Description: Sheet metal channel with fitted cover, suitable for use as surface metal raceway.

C. Finish: Gray or Buff enamel. Stainless steel.

D. Fittings, Boxes, and Extension Rings: Furnish manufacturer's standard accessories; match finish on raceway.

## 2.8 WIREWAY

A. Manufacturers:

1. Cooper B-Line.

2. Hubbell.

3. Walker Systems, Inc.

B. Product Description: General purpose, Oil tight and dust-tight, Rain tight type wireway.

C. Cover: Hinged or Screw cover.

D. Connector: Slip-in or Flanged.

E. Fittings: Lay-in type with removable top, bottom, and side; captive screws drip shield.

F. Finish: Rust inhibiting primer coating with gray enamel finish.

## 2.9 OUTLET BOXES

A. Manufacturers:

1. Raco.

2. Appleton.

3. Steel City.

B. Sheet Metal Outlet Boxes: NEMA OS 1, galvanized steel.

1. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; furnish 1/2 inch male fixture studs where required.

2. Concrete Ceiling Boxes: Concrete type.

C. Cast Boxes: NEMA FB 1, Type FD, cast feralloy. Furnish gasketed cover by box manufacturer. Furnish threaded hubs.

D. Wall Plates for Unfinished Areas: Furnish gasketed cover.

## 2.10 PULL AND JUNCTION BOXES

A. Manufacturers:

1. Raco.

2. Appleton.

3. Steel City.

B. Sheet Metal Boxes: NEMA OS 1, galvanized steel. NEMA 4 for exterior.

C. Surface Mounted Cast Metal Box: NEMA 250, Type 4; flat-flanged, surface mounted junction box:

1. Material: Galvanized cast iron.

2. Cover: Furnish with ground flange, neoprene gasket, and stainless steel cover screws.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Verify outlet locations and routing and termination locations of raceway prior to rough-in.

### 3.2 EXISTING WORK

A. Remove exposed abandoned raceway, including abandoned raceway above accessible ceiling finishes. Cut raceway flush with walls and floors, and patch surfaces.

B. Remove concealed abandoned raceway to its source.

C. Disconnect abandoned outlets and remove devices. Remove abandoned outlets when raceway is abandoned and removed. Install blank cover for abandoned outlets not removed.

D. Maintain access to existing boxes and other installations remaining active and requiring access. Modify installation or provide access panel.

E. Extend existing raceway and box installations using materials and methods compatible with existing electrical installations, or as specified.

F. Clean and repair existing raceway and boxes to remain or to be reinstalled.

### 3.3 INSTALLATION

A. Ground and bond raceway and boxes.

B. Fasten raceway and box supports to structure and finishes.

C. Identify raceway and boxes.

D. Arrange raceway and boxes to maintain headroom and present neat appearance.

E. All conduit shall be concealed from public view unless approved by LAWA.

### 3.4 INSTALLATION - RACEWAY

A. Raceway routing is shown in approximate locations unless dimensioned. Route to complete wiring system.

B. Arrange raceway supports to prevent misalignment during wiring installation.

C. Support raceway using coated steel or malleable iron straps, lay-in adjustable hangers, clevis hangers, and split hangers.

D. Group related raceway; support using conduit rack. Construct rack using steel channel; provide space on each for 25 percent additional raceways.

E. Do not support raceway with wire or perforated pipe straps. Remove wire used for temporary supports

F. Do not attach raceway to ceiling support wires or other piping systems.

G. Construct wireway supports from steel channel.

H. Route exposed raceway parallel and perpendicular to walls.

I. Conduit routed at 45 degree angles is not allowed at any time.

J. Route raceway installed above accessible ceilings parallel and perpendicular to walls.

K. Route conduit in and under slab from point-to-point.

L. Maintain clearance between raceway and piping for maintenance purposes.

M. Maintain 12 inch clearance between raceway and surfaces with temperatures exceeding 104 degrees F.

N. Cut conduit square using saw or pipe cutter; de-burr cut ends.

O. Bring conduit to shoulder of fittings; fasten securely.

P. Join nonmetallic conduit using cement as recommended by manufacturer. Wipe nonmetallic conduit dry and clean before joining. Apply full even coat of cement to entire area inserted in fitting. Allow joint to cure for minimum 20 minutes.

Q. Install conduit hubs or sealing locknuts to fasten conduit to sheet metal boxes in damp and wet locations and to cast boxes.

R. Install no more than equivalent of four 90 degree bends between boxes. Install conduit bodies to make sharp changes in direction, as around beams. Install hydraulic one-shot bender to fabricate factory elbows for bends in metal conduit larger than 2 inch size.

S. Avoid moisture traps; install junction box with drain fitting at low points in conduit system.

T. Install fittings to accommodate expansion and deflection where raceway crosses seismic, control and expansion joints.

U. Install suitable pull string or cord in each empty raceway except sleeves and nipples.

V. Install suitable caps to protect installed conduit against entrance of dirt and moisture.

W. Surface Raceway: Install flat-head screws, clips, and straps to fasten raceway channel to surfaces; mount plumb and level. Install insulating bushings and inserts at connections to outlets and corner fittings.

X. Close ends and unused openings in wireway.

Y. All conduit shall be routed above any mechanical ductwork not below.

3.5 INSTALLATION - BOXES

A. Install wall mounted boxes at elevations to accommodate mounting heights specified in section for outlet device.

B. Adjust box location up to 10 feet prior to rough-in to accommodate intended purpose.

C. Orient boxes to accommodate wiring devices oriented.

D. Install pull boxes and junction boxes above accessible ceilings and in unfinished areas only.

E. In Accessible Ceiling Areas: Install outlet and junction boxes no more than 6 inches from ceiling access panel or from removable recessed luminaire.

F. Locate flush mounting box in masonry wall to require cutting of masonry unit corner only. Coordinate masonry cutting to achieve neat opening.

G. Do not install flush mounting box back-to-back in walls; install with minimum 6 inches separation. Install with minimum 24 inches separation in acoustic rated walls.

H. Secure flush mounting box to interior wall and partition studs. Accurately position to allow for surface finish thickness.

I. Install stamped steel bridges to fasten flush mounting outlet box between studs.

J. Install flush mounting box without damaging wall insulation or reducing its effectiveness.

K. Install adjustable steel channel fasteners for hung ceiling outlet box.

L. Do not fasten boxes to ceiling support wires or other piping systems.

M. Support boxes independently of conduit.

N. Install gang box where more than one device is mounted together. Do not use sectional box.

O. Install gang box with plaster ring for single device outlets.

3.6 INTERFACE WITH OTHER PRODUCTS

A. Install conduit to preserve fire resistance rating of partitions and other elements.

B. Route conduit through roof openings for piping and ductwork or through suitable roof jack with pitch pocket. Coordinate location with roofing installation.

C. Locate outlet boxes within 6’ of luminaires.

D. Align adjacent wall mounted outlet boxes for switches, thermostats, and similar devices.

3.7 ADJUSTING

A. Adjust flush-mounting outlets to make front flush with finished wall material.

B. Install knockout closures in unused openings in boxes.

3.8 CLEANING

A. Clean interior of boxes to remove dust, debris, and other material.

B. Clean exposed surfaces and restore finish.

C. Refer to Identification for Electrical Systems for information pertaining to conduit labeling.

END OF SECTION

# SECTION 26 05 34
# FLOOR BOXES FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes floor boxes; floor box service fittings; and access floor boxes.

B. Verify the existing floor assembly construction and its ability to accommodate any additional floor penetrations without compromising structural integrity and any required fire rating.

### 1.2 REFERENCES

A. National Electrical Manufacturers Association:

1. NEMA OS 1 - Sheet Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.

### 1.3 SUBMITTALS

A. Product Data: Submit catalog data for floor boxes service fittings.

B. Samples: Submit two of each service fitting illustrating size, material, configuration, and finish.

### 1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of each floor box and poke-through fitting.

### 1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

## PART 2 – PRODUCTS

2.1 Pedestal type and poke thru type boxes are <u>not</u> allowed without written LAWA approval.

### 2.2 FLOOR BOXES

A. Manufacturers:

1. Wiremold Co.

2. Walker, Inc.

3. Hubbell.

B. Floor Boxes: NEMA OS 1.

C. Adjustability: Fully adjustable or semi-adjustable.

D. Material: Cast metal or formed steel.

2.3 FLUSH-COVER-TYPE COMBINATION FITTING

A. Manufacturers:

1. Walker, Inc.

2. Wiremold Co.

B. Material: Brass or Aluminum.

C. The specified material for the floor box cover shall be aesthetically compatible with the adjacent floor finish and be approved by LAWA.

2.4 FLUSH-COVER-SERVICE FITTING ACCESSORIES

A. Protective Ring: Brass or Aluminum finish.

B. Split Nozzle: Brass or Aluminum finish.

C. Carpet Ring: Brass or Aluminum finish.

2.5 ACCESS FLOOR BOX

A. Manufacturers:

1. Wiremold, Inc.

2. Tate.

3. Thomas & Betts Steel City.

B. Product Description: Sheet metal box suitable for mounting in access floor system.

PART 3 – EXECUTION

3.1 In order to avoid severing any existing structural reinforcement, use ground penetrating radar to

survey the existing concrete slab before cutting or drilling any new floor penetrations.

3.2 EXAMINATION

A. Verify locations of floor boxes and outlets in offices, and work areas prior to rough-in.

B. Verify openings in access floor are in proper locations.

3.3 EXISTING WORK

A. Disconnect abandoned service fitting devices and remove service fittings. Fill in hole for abandoned floor boxes. Remove abandoned boxes, fill in hole and restore to adjacent finished area.

B. Maintain access to existing floor boxes remaining active and requiring access. Modify installation or provide access panel.

C. Extend existing service fitting installations using materials and methods compatible with existing electrical installations, or as specified.

D. Clean and repair existing service fittings to remain or to be reinstalled.

3.4 INSTALLATION

A. Floor Box Requirements: Use cast floor boxes for installations in slab on grade; formed steel boxes are acceptable for other installations.

B. Set floor boxes aligned with adjacent floor finish.

C. When aligning floor boxes note that most of the existing floor within the terminals are not level. Align all new floor boxes totally flush with the adjacent floor finish on all sides.

D. Install boxes and fittings to preserve fire resistance rating of slabs and other elements, using materials and methods.

3.5 ADJUSTING

A. Adjust floor box flush with finish flooring material.

3.6 CLEANING

A. Clean interior of boxes to remove dust, debris, and other material.

END OF SECTION

# SECTION 26 05 44
# UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. This Section includes the following:

1. Ducts in concrete-encased duct banks.
2. Handholds and handhole accessories.
3. Manholes and manhole accessories.

### 1.2 REFERENCES

A. ANSI C2

B. NFPA 70

C. City of Los Angeles Electrical Code (LAEC)

D. ASTM 478

E. UL 651

F. NEMA TC-2, TC-3

G. ASTM 615

H. ASTM C990

I. AASHTO HS20

### 1.3 SUBMITTALS

A. Product Data: For the following:

1. Manhole and hand hole hardware.
2. Conduit and ducts, including elbows, bell ends, bends, fittings, and solvent cement.
3. Duct-bank materials, including spacers and miscellaneous components.

4. Warning tape. Detectable type.

B. Shop Drawings: Show fabrication and installation details for underground ducts and utility structures and include the following:

1. For manholes:

a. Duct sizes and locations of duct entries.

b. Reinforcement details.

c. Manholes cover design and engraving.

d. Step details.

e. Grounding details.

f. Dimensioned locations of cable rack inserts, pulling-in irons, and sumps.

2. For precast manholes and hand holes, Shop Drawings shall be signed and sealed by a qualified Professional Engineer, and shall show the following:

a. Construction of individual segments.

b. Joint details.

c. Design calculations.

C. Coordination Detailing Activity Drawings: Show duct profiles and coordination with other utilities and underground structures. Include plans and sections drawn to scale, and show all bends and location of expansion fittings.

D. Product Certificates: For concrete and steel used in underground precast manholes, according to ASTM C 858.

E. Product Test Reports: Indicate compliance of manholes with ASTM C 857 and ASTM C 858, based on factory inspection.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to the LAWA's Representative, and marked for intended use.

B. Comply with ANSI C2.

C. Comply with California Electric Code (NFPA 70) and City of Los Angeles Electrical Code

(LAEC).

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

B. Store precast concrete units at Project site as recommended by manufacturer to prevent physical damage.

C. Arrange so identification markings are visible.

D. Lift and support precast concrete units only at designated lifting or supporting points.

1.6 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving occupied facilities unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated.

1. Comply with LAWA power shut-down procedures.

2. Do not proceed with utility interruptions without LAWA's Representative written permission.

1.7 COORDINATION

A. Coordinate layout and installation of ducts, manholes, and handholes with final arrangement of other utilities and site grading, as determined in the field.

B. Coordinate elevations of ducts and duct-bank entrances into manholes and handholes with final profiles of conduits as determined by coordination with other utilities and underground obstructions. Revise locations and elevations from those indicated as required to suit field conditions and to ensure duct runs drain to manholes and handholes, and as approved by the LAWA Representative.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to 5 percent of amount installed.

PART 2 - PRODUCTS

## 2.1 PRODUCTS AND MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Underground Precast Concrete Utility Structures:

a. Jensen Precast.

b. Utility Vault Co.

c. Brooks.

2. Frames and Covers:

a. Alhambra Foundry

b. Campbell Foundry Co.

c. East Jordan Iron Works, Inc.

3. Nonmetallic Ducts and Accessories:

a. Carlon Electrical Products.

b. Cantex, Inc.

c. Certainteed Corp.; Pipe & Plastics Group.

## 2.2 DUCTS

A. Rigid Nonmetallic Conduit: NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by the same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

## 2.3 HAND HOLES

A. Cast-Metal Boxes: Cast aluminum, with outside flanges and recessed, gasketed cover for flush mounting and with non-skid finish and legend on cover. Unit, when buried, shall be designed to support AASHTO H10 loading for sidewalk and landscaped areas and HS20 for roadways, parking lots and loading docks.

B. Precast Handholes: Reinforced concrete, monolithically poured walls and bottom, with steel frame and access door assembly as the top of hand hole. Duct entrances and windows shall be located near corners to facilitate racking. Pulling-in irons and other built-in items shall be installed before pouring concrete. Cover shall have nonskid finish and legend. Unit, when buried, shall be designed to support AASHTO H10 loading for sidewalk and landscaped areas and HS20 for roadways, parking lots and loading docks. Cover Legend: All underground

pullbox covers shall have the following cast-in or bead welded and galvanized identification label permanently affixed to the exterior:

1. "ELEC-LV" for electrical power circuits 600 volts or less.

2. "ELEC-HV" for electrical power circuits over circuits over 600 volts.

3. "COMM" for communications circuits.

4. A custom 3-digit number shall be added to the cover. Contact the LAWA Engineer for number assignment. The minimum letter height shall be one (1) inch.

2.4 PRECAST MANHOLES

A. Precast Units: Interlocking mating sections, complete with accessories, hardware, and features as indicated. Include concrete knockout panels for conduit entrance and sleeve for ground rod.

B. Entry way diameter: 36 inches minimum.

C. Design and fabricate structure according to ASTM C 858.

D. Structural Design Loading: ASTM C 857, Class A-16 (AASHTO HS20).

E. Base section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.

F. Riser Sections: 4-inch minimum thickness, and lengths to provide required depth.

G. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings. Custom configuration for eccentric manhole locations to align with corridors.

H. Steps: ASTM A 615, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP, wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of manhole to finished grade is less than 36 inches. Adjust to custom manhole locations.

I. Grade Rings: Reinforced-concrete rings, 6- to 9-inch total thickness, to match diameter of manhole frame and cover.

J. Joint Sealant: ASTM C 990, bitumen or butyl rubber.

K. Protective Coating: Plant-applied, coal-tar, epoxy-polyamide paint 15-mil minimum thickness applied to exterior and interior surfaces.

L. Source Quality Control: Inspect structures according to ASTM C 1037.

M. Provide custom top section for offset manhole location for alignment with corridor for below building installation.

N. Access Ladder: Provide permanent metal access ladder.

2.5 ACCESSORIES

A. Duct Spacers: Rigid PVC interlocking spacers, selected to provide minimum duct spacings and cover depths indicated while supporting ducts during concreting and backfilling; produced by the same manufacturer as the ducts.

B. Manhole Frames and Covers: Comply with AASHTO loading specified for manhole; Ferrous frame 36-inch clear ID by 6 inch minimum riser with 4-inch-minimum width flange and 38-inch diameter cover.

1. All manhole and underground pullbox covers shall have the following cast-in or bead welded and galvanized identification label permanently affixed to the exterior:

a. "ELEC-LV" for electrical power circuits 600 volts or less.

b. "ELEC-HV" for electrical power circuits over circuits over 600 volts.

c. "COMM" for communications circuits.

d. A custom 3-digit number shall be added to the cover. Contact the LAWA Engineer for number assignment. The minimum letter height shall be one (1) inch.

2. Cast iron with cast-in legend as indicated above subsection 1. Milled cover-to-frame bearing surfaces.

3. Manhole Frames and Covers: ASTM A 48; Class 30B gray iron, 36-inch size, machine-finished with flat bearing surfaces.

C. Sump Frame and Grate: ASTM A 48, Class 30B gray cast iron.

D. Pulling Eyes in Walls: Eyebolt with reinforcing-bar fastening insert 2-inch- diameter eye and 1-inch by 4-inch bolt.

1. Working Load Embedded in 6-Inch, 4000-psi Concrete: 13,000-lbf minimum tension.

E. Pulling and Lifting Irons in Floor: 7/8-inch- diameter, hot-dip-galvanized, bent steel rod; stress relieved after forming; and fastened to reinforced rod. Exposed triangular opening.

1. Ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.

F. Bolting Inserts for Cable Stanchions: Flared, threaded inserts of noncorrosive, chemical-

resistant, nonconductive thermoplastic material; 1/2-inch ID by 2-3/4 inches deep, flared to 1-1/4 inches minimum at base.

1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.

G. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch bolt, 5300-lbf rated pullout strength, and minimum 6800-lbf rated shear strength.

H. Cable Stanchions: Hot-rolled, hot-dip-galvanized, T-section steel; 2-1/4-inch size; punched with 14 holes on 1-1/2-inch centers for cable-arm attachment.

I. Cable Arms: 3/16-inch- thick, hot-rolled, hot-dip-galvanized, steel sheet pressed to channel shape; 12 inches wide by 14 inches long and arranged for secure mounting in horizontal position at any location on cable stanchions.

J. Cable-Support Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.

K. Duct-Sealing Compound: Non-hardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F. Capable of withstanding temperature of 300 deg F without slump and of adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

L. Warning Tape: Provide underground-line warning tape specified under section "Identification for Electrical Systems."

## 2.6 CONSTRUCTION MATERIALS

A. Seal manhole section joints with sealing compound recommended by the manhole manufacturer.

B. Damp proofing: Comply with "Bituminous Damp proofing."

C. Mortar: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. where packaged mix complying with ASTM C 387, Type M, may be used.

D. Brick for Manhole Chimney: Sewer and manhole brick, ASTM C 32, Grade MS.

E. Concrete: Use 3000-psi- minimum, 28-day compressive strength and 1-inch maximum aggregate size.

F. Provide red dye added to concrete during batching.

# PART 3 - EXECUTION

## 3.1 APPLICATION

A. Underground Ducts for Electrical Cables Higher than 600 V: Type EPC-40-PVC, concrete encased duct bank.

B. Manholes: Underground precast concrete utility structures.

C. Manholes: Cast-in-place concrete.

## 3.2 EARTHWORK

A. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Soil compaction at all locations shall be as specified by civil and structural specifications.

B. Restore all areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary top soiling, fertilizing, liming, seeding, sodding, sprigging, and mulching.

C. Restore disturbed pavement.

## 3.3 CONDUIT AND DUCT INSTALLATION

A. Exercise care in excavating, trenching, and working near existing utilities. Locate any existing buried utilities before excavating.

B. Duct bank trench shall be shored, framed and braced for installing ducts. Frames, forms, and braces shall be either wood or steel. Variations in outside dimensions of the installed duct bank shall not exceed 2 inches on the vertical or the horizontal from the design. Remove forms and bracing after 24 hours and before backfilling.

C. 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. Duct banks shall be laid to a minimum grade slope of 4 inches per 100 feet. This slope may be from one manhole to the next or both ways from a high point between manholes, depending upon the contour of the finished grade.

D. Duct banks shall be installed so that the top of the concrete encasement shall be no less than 36 inches below grade or pavement for primary power. As a general rule, depths shall be a minimum of three feet, but not more than six feet.

E. Curves and Bends: Use manufactured 48 inches minimum elbows for stub-ups at equipment, and enclosures, and at building entrances. Use manufactured long sweep bends with a minimum radius of 4 feet minimum, both horizontally and vertically, at other locations. Manufactured long radius bends may be used in runs of 100 feet or less on approval from the LAWA's representative. Vertical feeder sweep into buildings shall be coated steel. Multiple conduit sweeps shall be concentric and maintain spacing throughout. Medium-voltage conduit sweeps shall be 12'

minimum radius sweeps.

F. Use solvent-cement 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 the same plane.

G. Duct Entrances to Manholes and Handholes: Space end bells approximately 10 inches o.c. for 5-inch ducts and vary proportionately for other duct sizes. Change from regular spacing to end-bell spacing 10 feet from the end bell without reducing duct line slope and without forming a trap in the line. Grout end bells into manhole walls from both sides to provide watertight entrances. Where connection to bulkhead of duct bank is made to vaults or existing duct banks, the concrete encasement shall be doweled with on No. 4 reinforcement rod 36 inches long per conduit to the existing encasement.

H. Building Entrances: Make a transition from underground duct to rigid steel conduit 5 feet outside the building wall. Use fittings manufactured for this purpose. Follow the appropriate installation instructions below:

1. Concrete-Encased Ducts: Install reinforcement in duct banks passing through disturbed earth near buildings and other excavations. Coordinate duct bank with structural design to support duct bank at wall without reducing structural or watertight integrity of building wall. Expand duct bank at building entry to provide 6” spacing between sealing system sleeves. Coordinate sleeve placement with structural reinforcement bar placement.

2. Provide methane penetration EYS sealing fitting at each conduit penetration into building.

3. Waterproofed Wall and Floor Penetrations: Install a watertight entrance-sealing device with sealing gland assembly on the inside. Anchor device into masonry construction with one or more integral flanges. Secure membrane waterproofing to the device to make permanently watertight. Seals shall be Link Seal. Assembly with precast ‘CS” model – non-metallic sleeve by Link Seal or equal.

4. All permanent underground ducts are to be concrete encased as described herein.

I. Concrete-Encased, Nonmetallic Ducts: Support ducts on duct spacers, spaced as recommended by manufacturer and coordinated with duct size, duct spacing, and outdoor temperature. Install as follows:

1. Separator Installation: Space separators 6’-0” O.C. to prevent sagging and deforming of ducts and secure separators to earth and to ducts to prevent floating during concreting. Stagger spacers approximately 6 inches 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.

2. Duct joints in concrete may be placed side by side horizontally, but shall be staggered at least 6 inches vertically. Joints shall be made in accordance with manufacturer’s recommendations for the particular type of duct and coupling selected. In the absence of

specific recommendations, plastic duct connections shall be made by brushing a plastic solvent cement on the inside of a plastic coupling fitting and on the outside of duct's ends. The duct and fitting shall then be slipped together with a quick one-quarter turn to set the joint.

3. Concreting: 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. Pour each run of envelope between manholes or other terminations in one continuous operation. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing rod dowels extending 18 inches into concrete on both sides of joint near corners of envelope. At connection to manholes, dowel concrete encasement with on No. 4 reinforcing bar 36 inches long per duct.

4. Reinforcement: Reinforce duct banks where they cross disturbed earth and where indicated.

5. 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.

6. Minimum Clearances between Ducts: 3 inches between ducts and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and signal ducts.

7. Depth: Install top of duct bank at least 24 inches below finished grade in no traffic areas and at least 30 inches below finished grade in vehicular traffic areas, unless otherwise indicated.

8. Direct-Buried Ducts are for <u>temporary</u> construction only as determined by LAWA

J. Direct-Buried Ducts: Support ducts on duct spacers, spaced as recommended by manufacturer and coordinated with duct size, duct spacing, and outdoor temperature. Install as follows:

1. Separator Installation: Space separators not more than 4 feet center-to-center along entire length of duct bank including top pipes.

2. Install expansion fittings as required.

3. Trench Bottom: Continuous, firm, and uniform support for duct bank. Prepare trench bottoms for pipes less than 6 inches in nominal diameter.

4. Backfill: Install backfill. After installing first tier of ducts, backfill and compact. Repeat backfilling after placing each tier. After placing last tier, hand-place backfill to 4 inches 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, complete backfilling normally. Do not place backfill for a period of at least 24 hours after pouring of concrete.

5. Minimum Clearances between Ducts: 3 inches between ducts for like services and 6 inches between power and signal ducts.

6. Depth: Install top of duct bank at least 36 inches below finished grade, unless otherwise indicated.

K. Warning Tape: Bury metal backed warning tape approximately 12 inches above all concrete-encased duct banks. Align tape parallel to and within 3 inches of the centerline of duct bank.

L. Stub-ups: Use rigid steel conduit for stub-ups to equipment. For equipment mounted on outdoor concrete bases, extend steel conduit a minimum of 5 feet from edge of base. Install insulated grounding bushings on terminations. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3 inches of concrete. Galvanized steel conduits installed below grade shall be painted with two coats. It is not acceptable to install conduit hubs on conduits terminating in the disconnect switch and the ground wire through the conduit and connect to the disconnect housing in lieu of a ground bushing.

M. 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 hydrostatic pressure.

N. Pulling Cord: Install 100-lbf- test nylon cord in all ducts, including spares. Identify opposite terminal points of duct.

O. 10-mil tape is acceptable in lieu of paint.

## 3.4 MANHOLE AND HANDHOLE INSTALLATION

A. Elevation: Install manholes with rooftop at least 15 inches below finished grade. Install handholes with depth as required. Cast hand hole cover frame directly into roof of hand hole and set roof surface 1 inch above grade. Place and align precast manholes to provide horizontal tolerance of 2 inches in any direction and vertical alignment with not greater than 1/8 inch maximum tolerance for 6 foot of depth. Completed manhole shall be rigid, true to dimensions and alignment, and shall be watertight.

B. Drainage: Install drains in bottom of units where indicated. Coordinate with drainage provisions indicated. Sumps shall be knocked out at time of installation.

C. Access: Install cast-iron frame and cover.

1. Install precast collars and rings to support frame and cover and to connect cover with roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney.

2. Set frames in paved areas and traffic ways flush with finished grade. Set other frames 1 inch above finished grade.

D. Waterproofing: Apply waterproofing to exterior surfaces of units after concrete has cured at least three days. After ducts have been connected and grouted, and before backfilling, waterproof joints and connections and touch up abrasions and scars. Waterproof exterior of manhole and hand hole chimneys after brick mortar has cured at least three days. Seal manhole section joints with sealing compound recommended by the manhole manufacturer. Penetration into manholes and/or boxes shall be sealed. Provide conduit duct plugs for unused terminator openings of spare conduits in manhole. Do not water seal top removable cover until cable pulling has been completed.

E. Damp proofing: Apply damp proofing to exterior surfaces of units after concrete has cured at least three days. After ducts have been connected and grouted, and before backfilling, damp proof joints and connections and touch up abrasions and scars. Damp proof exterior of manhole and hand hole chimneys after brick mortar has cured at least three days.

F. Interior walls and ceiling shall be primed and painted with two coats flat white paint.

G. Hardware: 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.

H. Field-Installed Bolting Anchors: Do not drill deeper than 3-7/8 inches for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

I. Grounding: Install ground rod through floor in each structure with top protruding 6 inches above floor.

1. Seal floor opening against water penetration with waterproof non-shrink grout. Ground exposed metal components and hardware with bare-copper ground conductors. Train conductors neatly around corners. Use cable clamps secured with expansion anchors to attach ground conductors.

J. Precast Concrete Manhole Installation: Comply with ASTM C 891.

1. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.

2. Unless otherwise indicated, support units on a 12” level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth. Provide a minimum 6-inch level base of ¾ inch crushed rock under manhole to ensure uniform distribution of soil pressure on floor.

3. Manholes below building floor shall have all earth work compacted to match compaction required by structural specifications.

## 3.5 FIELD QUALITY CONTROL

A. Testing: Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.

B. Grounding: Test manhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance .

C. Duct Integrity: 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 the duct. If obstructions are indicated, remove obstructions and retest.

D. Correct installations if possible and retest to demonstrate compliance. Remove and replace defective products and retest.

3.6 CLEANING

A. 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.

B. Clean internal surfaces of manholes, including sump. Remove foreign material.

C. After the duct line has been completed, a brush with stiff bristles shall be pulled through each duct to make certain that no particles of earth, sand or gravel have been left in the line. (Mandrels not less than 12 inches long, having a diameter approximately 1/4 inch less than inside diameter of the duct, shall be pulled through each duct). Leave a 3/8”-inch minimum polypropylene pull rope in each duct for future use.

END OF SECTION

# SECTION 26 05 49
# VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. This Section includes seismic restraints and other earthquake-damage-reduction measures for electrical components. It complements optional seismic construction requirements in the various electrical component Sections.

### 1.2 REFERENCES

A. ASTM A325, A570, A36, A576

B. CBC

C. IC80

D. MSS SP-69

### 1.3 DEFINITIONS

A. CBC: California Building Code. (Sections 1704 through 1708), IBC: International Building Code.

B. Seismic Restraint: A fixed device (a seismic brace, an anchor bolt or stud, or a fastening assembly) used to prevent vertical or horizontal movement, or both vertical and horizontal movement, of an electrical system component during an earthquake.

C. Mobile Structural Element: A part of the building structure such as a slab, floor structure, roof structure, or wall that may move independent of other mobile structural elements during an earthquake.

### 1.4 SUBMITTALS

A. Product Data: Illustrate and indicate types, styles, materials, strength, fastening provisions, and finish for each type and size of seismic restraint component used.

1. Anchor Bolts and Studs: Tabulate types and sizes, complete with report numbers and rated strength in tension and shear as evaluated by ICBO Evaluation Service.

B. Shop Drawings: Provide for anchorage and bracing not defined by details and charts. Indicate materials, and show designs and calculations signed and sealed by a professional Engineer.

1. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.

2. Details: Detail fabrication and arrangement. Detail attachment of restraints to both structural and restrained items. Show attachment locations, methods, and spacing, identifying components and listing their strengths. Indicate direction and value of forces transmitted to the structure during seismic events.

3. Pre-Approval and Evaluation Documentation: By ICBO Evaluation Service, or an agency approved by LAWA's Representative, showing maximum ratings of restraints and the basis for approval (tests or calculations).

C. Coordination Drawings: Plans and sections drawn to scale and coordinating seismic bracing for electrical components with other systems and equipment, including other seismic restraints, in the vicinity.

D. Product Certificates: Signed by manufacturers of seismic restraints certifying that products furnished comply with requirements.

E. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

F. Material Test Reports: From a qualified testing agency indicating and interpreting test results of seismic control devices for compliance with requirements indicated.

## 1.5 QUALITY ASSURANCE

A. Comply with seismic restraint requirements in California Building Code/Code of Regulations, unless requirements in this Section are more stringent.

B. Professional Engineer Qualifications: A professional Engineer who is legally qualified to practice in California and who is experienced in providing seismic engineering services, including the design of seismic restraints.

C. Testing Agency Qualifications: An independent testing agency, acceptable to LAWA with minimum of 5 years' experience.

## 1.6 PROJECT CONDITIONS

A. Project Seismic Zone and Zone Factor as Defined in CBC: Zone 4, Zone Factor 0.40.

B. Occupancy Category as Defined in CBC: I=1.5 critical occupancy.

## 1.7 COORDINATION

A. Coordinate layout and installation of seismic bracing with building structural system and Architectural features, and with mechanical, fire-protection, electrical, and other building features in the vicinity.

B. Coordinate concrete bases with building structural system.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Caldyn

2. Powerstrut.

3. Unistrut Corporation.

### 2.2 MATERIALS

A. Use the following materials for restraints:

1. Indoor Dry Locations: Steel, zinc plated.

2. Outdoors and Damp Locations: Galvanized steel.

3. Corrosive Locations: Stainless steel.

### 2.3 ANCHORAGE AND STRUCTURAL ATTACHMENT COMPONENTS

A. Strength: Defined in reports by ICBO Evaluation Service or another agency acceptable to LAWA's Representative.

1. Structural Safety Factor: Strength in tension and shear of components used shall be at least two times the maximum seismic forces to which they will be subjected.

B. Concrete and Masonry Anchor Bolts and Studs: Steel-expansion wedge type.

C. Concrete Inserts: Steel-channel type.

D. Through Bolts: Structural type, hex head, high strength. Comply with ASTM A 325.

E. Welding Lugs: Comply with MSS SP-69, Type 57.

F. Beam Clamps for Steel Beams and Joists: Double sided. Single-sided type is not acceptable.

G. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to the type and size of anchor bolts and studs used.

H. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to the type and size of attachment devices used.

## 2.4 SEISMIC BRACING COMPONENTS

A. Slotted Steel Channel: 1-5/8-by-1-5/8-inch cross section, formed from 0.1046-inch- thick steel, with 9/16-by-7/8-inch slots at a maximum of 2 inches o.c. in webs, and flange edges turned toward web.

1. Materials for Channel: ASTM A 570, GR 33.

2. Materials for Fittings and Accessories: ASTM A 575, ASTM A 576, or ASTM A 36.

3. Fittings and Accessories: Products of the same manufacturer as channels and designed for use with that product.

4. Finish: Baked, rust-inhibiting, acrylic-enamel paint applied after cleaning and phosphate treatment, unless otherwise indicated.

B. Channel-Type Bracing Assemblies: Slotted steel channel, with adjustable hinged steel brackets and bolts.

C. Cable-Type Bracing Assemblies: Zinc-coated, high-strength steel wire rope cable attached to steel thimbles, brackets, and bolts designed for cable service.

1. Arrange units for attachment to the braced component at one end and to the structure at the other end.

2. Wire Rope Cable: Comply with ASTM 603. Use 49- or 133-strand cable with a minimum strength of 2 times the calculated maximum seismic force to be resisted.

D. Hanger Rod Stiffeners: Slotted steel channels with internally bolted connections to hanger rod.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Install seismic restraints according to applicable codes and regulations and as approved by the LAWA's Representative, unless more stringent requirements are indicated.

## 3.2 STRUCTURAL ATTACHMENTS

A. Use bolted connections with steel brackets, slotted channel, and slotted-channel fittings to spread structural loads and reduce stresses in accordance with the structural Engineer of record approval.

B. Attachments to New Concrete: Bolt to channel-type concrete inserts or use expansion anchors.

C. Attachments to Existing Concrete: Use expansion anchors.

D. Holes for Expansion Anchors in Concrete: Drill at locations and to depths that avoid reinforcing bars.

E. Attachments to Solid Concrete Masonry Unit Walls: Use expansion anchors.

F. Attachments to Hollow Walls: Bolt to slotted steel channels fastened to wall with expansion anchors.

G. Attachments to Steel: Bolt to clamps on flanges of beams or on upper truss chords of bar joists.

## 3.3 ELECTRICAL EQUIPMENT ANCHORAGE

A. Anchor rigidly to a single mobile structural element or to a concrete base that is structurally tied to a single mobile structural element.

B. Anchor panel boards, motor-control centers, motor controls, switchboards, switchgear, transformers, unit substations, fused power-circuit devices, transfer switches, busways, battery racks, static uninterruptible power units, power conditioners, capacitor units, communication system components, and electronic signal processing, control, and distribution units as follows:

1. Size concrete bases so expansion anchors will be a minimum of 10 bolt diameters from the edge of the concrete base.

2. Concrete Bases for Floor-Mounted Equipment: Use female expansion anchors and install studs and nuts after equipment is positioned.

3. Bushings for Floor-Mounted Equipment Anchors: Install to allow for resilient media between anchor bolt or stud and mounting hole in concrete.

4. Anchor Bolt Bushing Assemblies for Wall-Mounted Equipment: Install to allow for resilient media where equipment or equipment-mounting channels are attached to wall.

5. Torque bolts and nuts on studs to values recommended by equipment manufacturer.

## 3.4 SEISMIC BRACING INSTALLATION

A. Install bracing according to spacing and strengths indicated by approved analysis.

B. Expansion and Contraction: Install to allow for thermal movement of braced components.

C. Cable Braces: Install with maximum cable slack recommended by manufacturer.

D. Attachment to Structure: If specific attachment is not indicated, anchor bracing to the structure at flanges of beams, upper truss chords of bar joists, or at concrete members.

## 3.5 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Make flexible connections in raceways, cables, wire ways, cable trays, and busways where they cross expansion and seismic control joints, where adjacent sections or branches are supported by different structural elements, and where they terminate at electrical equipment anchored to a different mobile structural element from the one supporting them.

## 3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform the following field quality-control testing:

B. Testing: Test pull-out resistance of seismic anchorage devices.

1. Provide necessary test equipment required for reliable testing.

2. Provide evidence of recent calibration of test equipment by a testing agency acceptable to LAWA’s Representative.

3. Schedule test with the LAWA Representative before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven days' advance notice.

4. Obtain Structural Engineer’s approval before transmitting test loads to the structure. Provide temporary load-spreading members.

5. Test at least four of each type and size of installed anchors and fasteners selected by LAWA’s Representative.

6. Test to 90 percent of rated proof load of device.

7. If a device fails the test, modify all installations of same type and retest until satisfactory results are achieved.

8. Record test results.

END OF SECTION

# SECTION 26 05 54
# IDENTIFICATION FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Nameplates.
2. Labels.
3. Wire markers.
4. Conduit markers.
5. Stencils.
6. Underground Warning Tape.
7. Lockout Devices.

### 1.2 SUBMITTALS

A. Product Data:

1. Submit manufacturer’s catalog literature for each product required.
2. Submit electrical identification schedule including list of wording, symbols, letter size, color coding, tag number, location, and function.

B. Manufacturer's Installation Instructions: Indicate installation instructions, special procedures, and installation.

### 1.3 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of tagged devices; include tag numbers.

### 1.4 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.

B. Installer: Company specializing in performing Work of this section with minimum three years documented experience and approved by manufacturer.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Accept identification products on site in original containers. Inspect for damage.

B. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.

C. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.6 ENVIRONMENTAL REQUIREMENTS

A. Install labels and nameplates only when ambient temperature and humidity conditions for adhesive are within range recommended by manufacturer.

PART 2 - PRODUCTS

2.1 NAMEPLATES ON EQUIPMENT

A. All new distribution switchboards panels transformers VFD(s), ATS(s) and other electrical distribution equipment shall have Engraved Plastic Nameplates and Signs:

1. Engraving stock, melamine plastic laminate, minimum 1116 inch (1.6 mm) thick for signs up to 20 sq. in. (129 sq. cm) and 1/8 Inch (3.2 mm) thick for larger sizes. Engraved legend with white letters on black face for normal power, white letters on red face for emergency power.

a. Punched or drilled for mechanical fasteners.

b. Text is at ½ -inch (13 mm) high lettering.

B. With the following Information for each panel:

1. PANEL Name (Including voltage, phase, and wire)

2. LAWA or CONCESSIONS or AIRLINE

3. FED FROM (Source Panel Name)

C. Nameplates shall be secured to equipment front using screws or rivets.

D. Nameplates shall adequately describe the function of the particular equipment involved. Inscription and size of letters shall be as shown and shop drawing submitted for approval. Nameplates for panelboards and switchboards shall include the panel designation, voltage, phase and wire. For example, "PANEL A. 120/208V, 3PH, 4W". In addition, provide phenolic label in panel to describe where the panel is fed from. For example, "FED FROM MS". The name of the machine on the nameplates for a particular machine shall be the same as the one used on all motor starters, disconnect and push button station nameplates for that machine.

E. The following Items shall be equipped with nameplates: All motors, motor starters, motor-control centers. Push button stations, control panels, switches, disconnect switches, transformers, panelboards, circuit breakers (i.e. all 2 pole, 3 pole C.B.'s). contractors or relays in separate enclosures, power receptacles where the nominal voltage between any pair of contacts is greater than 150V, wall switches controlling outlets that are not located within sight of the controlling switch, high voltage boxes and cabinets, large electrical systems Junction and pull boxes (larger than 4 11/16"), terminal cabinets, terminal boards, and equipment racks. Nameplates shall also describe the associated panel and circuit number (if applicable).

F. Stamped metal master nameplates shall be installed on each distribution section, switchboard section, panelboard, and motor control center indicating the board designation, voltage, ampere rating, short-circuit rating, manufacturer's name, general order number, and item number.

G. Arc Flash Nameplate with PPE category information.

2.2 PERMANENT MARKINGS

A. All switches, devices, conduits, busways, cable trays and pullboxes shall be identified with permanent stenciled black letters and numbers which indicate the source panel (feeder supply source), circuit numbers and designated panel or load. For example, “PA-1, 3, 5 TO MG.” For conduits, the letter height shall be one-third (1/3) the conduit size with ¼ inch minimum height. For pullboxes and busways, the letter height shall be ½ inch minimum height and not larger than ¾ inch in height.

B. The identifications for conduits, busways and cable trays shall be placed at every 50 feet intervals and within 10 feet of wall and floor penetrations, pullboxes, panels, distribution boards, switchboards and electrical equipment.

C. Spare conduits, pullboxes, busways, and abandoned raceways (that are to remain) shall be identified as described above (A, B).

D. The permanent marking identifications on the raceways and pullboxes shall be visible after the installations are made.

E. All receptacle and switch faceplates shall be labeled with the source panel and circuit number. The label shall be black Arial font on white or clear tape, produced by a P-Touch or other label machine.

F. All boxes and enclosures (including transfer switches, generators, and power panels) for emergency circuits shall be permanently marked in red with the words, "EMERGENCY SYSTEM", so they will be readily identified as a component of an emergency circuit or system.

## 2.3 LABELS

A. Labels: Embossed adhesive tape, with 3/16 inch black letters on white background for normal power; white letters on red background for emergency power.

## 2.4 WIRE MARKERS

A. Description: Cloth tape, split sleeve, or tubing type wire markers.

B. Legend:

1. Power and Lighting Circuits: Branch circuit or feeder number.

2. Control Circuits: Control wire number.

## 2.5 CONDUIT AND RACEWAY MARKERS

A. Description: Permanent, detectable, red colored, continuous printed, polyethylene tape with suitable warning legend describing burial electrical lines. Taps shall be minimum 6 inches wide by 4 mils thick.

B. Color:

1. (Normal Power): Black lettering on white background;

2. (Emergency Power): White lettering on red background.

C. Legend:

1. Medium Voltage System: 5k, 15kV or 35kV as applicable.

2. 480 Volt System: 480 VOLTS.

3. 208 Volt System: 208 VOLTS.

## 2.7 LOCKOUT DEVICES

A. Lockout Hasps:

1. Anodized aluminum hasp with erasable label surface; size minimum 7-1/4 x 3 inches.

PART 3 - EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

3.2 INSTALLATION

A. Install identifying devices after completion of painting.

B. Nameplate Installation:

1. Install nameplate parallel to equipment lines.

2. Install nameplate for each electrical distribution and control equipment enclosure with corrosive-resistant mechanical fasteners.

3. Install nameplates for each control panel and major control components located outside panel with corrosive-resistant mechanical fasteners.

4. Secure nameplate to equipment front using screws, or rivets.

5. Secure nameplate to inside surface of door on recessed panelboard in finished locations.

6. Install nameplates for the following:

a. Panelboards/Switchboxes.

b. Transformers.

c. Disconnect Switches

d. Enclosed circuit breakers.

e. Terminal cabinet.

7. Install nameplate to maintain NEMA rating of enclosure.

C. Label Installation:

1. Install label parallel to equipment lines.

2. Install label for identification of individual control device stations.

3. Install labels for permanent adhesion and seal with clear lacquer.

4. Wire Marker Installation:

a. Install wire marker for each conductor at panelboard gutters, pull boxes, outlet and junction boxes, and each load connection.

b. Mark data cabling at each end. Install additional marking at accessible locations along the cable run.

c. Install labels at data outlets identifying patch panel and port designation.

d. All electrical conduits shall have circuit labels before penetrating each wall or floor, handwritten, clear and legible, using permanent marker, i.e., Sharpie brand permanent marker.

e. Use permanent marker for junction and pullboxes; do not use P-touch brand label maker.

f. For exterior boxes and devices, use phenolic riveted or screwed to the box cover; do not use P-touch brand label maker.

g. Phenolic equipment designation name plate is acceptable provided that they are riveted or screwed; do not use stickers or glue. This also applies to switchgear, switchboards, transformers, panelboards, VFD's, disconnect switches, etc.

h. The manufacturer's metal name plate shall be riveted or screwed with information, per Specification Section 26 0544, 2.2.F.

i. Use Arial font.

j. For IT cabinets/racks/enclosures, use black in color, phenolic 1/2-inch with letter on white background, with identification number and row.

k. For disconnect switches, use phenolic with 3/16-inch white letters on black (normal) or red (emergency) background with equipment designation, indicating what the device feeds and where it is fed from.

l. For VFD's, use phenolic with 3/16-inch white letters on black (normal) or red (emergency) background with equipment designation, indicating what the device feeds and where it is fed from.

m. For panels, use phenolic with 3/8-inch white letters on black (normal) or red (emergency) background with equipment designation, indicating LAWA, TSA or Concessions and fed from source, i.e., FED FROM PNL 3S4LP5.

n. For XFRM, use phenolic with 3/8-inch white letters on black (normal) or red (emergency) background with equipment designation, indicating LAWA, TSA or Concessions and fed from source, i.e., FED FROM PNL 3S4LP5.

o. For switchgear, use phenolic with 1/2-inch white letters on black (normal) or red

(emergency) background with equipment designation, indicating LAWA, TSA or Concessions and fed from source, i.e., FED FROM PNL 3S4LP5.

p. For switchboards, use phenolic with 1/2-inch white letters on black (normal) or red (emergency) background with equipment designation, indicating LAWA, TSA or Concession and fed from source, i.e., FED FROM PNL3S4LP5.

END OF SECTION

# SECTION 26 05 73
# SHORT CIRCUIT, ARC FLASH AND OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

## PART 1 - GENERAL

### 1.1 SUMMARY

A. This section includes computer-based, fault current and overcurrent protective devices coordination including ground fault protection and arc fault hazard analysis studies to be performed by the contractor. Protective devices shall be set based on the result of the protective device coordination study. Arc fault hazard analysis warning nameplates shall be printed and affixed to the electrical system equipment after the final protective relay settings have been applied and confirmed operational. Settings and adjustments of the relays shall be performed by an independent qualified agency familiar with this work and the agency is to be retained by the contractor. The person performing this work shall have a minimum of five years experience.

B. This coordination study shall include the existing distribution equipment that feeds the new equipment and is in addition to the short circuit study performed by the Electrical Engineer of Record during the course of preparing his design.

C. Contractor shall retain a 3rd party independent consultant to perform the study indicated in this section. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the supervision and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies. The Registered Professional Electrical Engineer shall be a full-time employee of the Engineering Services Organization and be registered in the State of California.

D. It is the responsibility of the entity performing the Short Circuit and Coordination Study to collect all data to fully perform the study, including but not limited to engine generator data, motor data, circuit breakers, utility company short circuit, available new and existing device ratings, conductor data, transformer ratings, etc.

D. The study shall present an organized time-current analysis of each protective device in series from the individual device back to the source. The study shall reflect the operation of each device ratings, conductor data, transformer ratings, etc.

E. The short circuit portion of the study shall be submitted prior to or along with the switchgear submittal, and shall include all equipment which has an AIC rating. The short circuit study shall reflect that all equipment with an AIC rating is properly rated for its specific application. The submitted switchgear (including all equipment which has and AIC rating) shall reflect the findings of short circuit study (i.e, the AIC ratings of the equipment shall exceed the available short circuit current and any required derating factors at each point in the system). Series ratings are not acceptable.

1.2 REFERENCES

A. Institute of Electrical and Electronics Designers:

1. IEEE 242 - Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (Buff Book).

2. IEEE 1584 – 2002 (Guide for Performing Arc-Flash Hazard Calculations)

B. National Fire Protection Association:

1. NFPA 70 - National Electrical Code.

2. NFPA 70E – Standard for Electrical Safety in the Workplace.

1.3 DESIGN REQUIREMENTS

A. Complete Short Circuit, Arc Flash and Protective Device Coordination Study to meet requirements of NFPA 70, NFPA 70E and IEEE 1584.

B. Report Preparation:

1. Prepare study prior to ordering distribution equipment to verify equipment ratings required.

2. Perform study with aid of computer software program.

3. Calculate short circuit interrupting and, when applicable, momentary duties for assumed 3-phase bolted fault short circuit current and phase to ground fault short circuit current at each of the following:

a. Utility supply bus.

b. Medium voltage air interrupter switchgear.

c. Automatic transfer switch.

d. Manual transfer switch.

e. Engine generator.

f. Medium voltage motor controllers.

g. Low-voltage switchgear.

h. Switchboards.

i. Motor control centers.

j. Distribution panelboards.

k. Branch circuit panelboards.

4. Each other significant equipment location throughout system.

C. Report Contents (similar to SKM Power Tools):

1. Include the following:

a. Calculation methods and assumptions.

b. Base per unit value selected.

c. One-line diagram, with short circuit values, arc flash values, feeder values and lengths.

d. Source impedance data including power company system available power and characteristics.

e. Typical calculations.

1) Fault impedance.

2) X to R ratios.

3) Asymmetry factors.

4) Motor fault contribution.

5) Short circuit kVA.

6) Symmetrical and asymmetrical phase-to-phase and phase-to-ground fault currents.

7) Tabulations of calculation quantities and results.

f. One-line diagram revised by adding actual instantaneous short circuits available.

g. State conclusions and recommendations.

1) Prepare time-current device coordination curves graphically indicating coordination proposed for system, centered on conventional, full-size, log-log forms.

2) Prepare with each time-curve sheet complete title and one-line diagram with legend identifying specific portion of system covered by that particular curve sheet.

3) Prepare detailed description of each protective device identifying its type, function, manufacturer, and time- current characteristics. Tabulate recommended device tap, time dial, pickup, instantaneous, and time delay settings.

4) Plot device characteristic curves at point reflecting maximum symmetrical fault current to which device is exposed. Include on curve sheets the following:

h. Power company relay characteristics.

i. Power company fuse characteristics.

j. Medium voltage equipment protective relay characteristics.

k. Medium voltage equipment protective fuse characteristics.

l. Low voltage equipment circuit breaker trip device characteristics.

m. Low voltage equipment fuse characteristics.

n. Cable damage point characteristics.

o. Pertinent transformer characteristics including:

1) Transformer full load current.

2) Transformer magnetizing inrush.

3) ANSI transformer withstand parameters.

4) Significant symmetrical fault current.

p. Pertinent motor characteristics.

q. Generator characteristics including:

1) Phase and ground coordination of generator protective devices.

2) Decrement curve and damage curve.

3) Operating characteristic of protective devices.

4) Actual impedance value.

5) Time constants.

6) Current boost data.

7) Do not use typical values for generator.

r. Transfer switch characteristics.

s. Other system load protective device characteristics.

t. Incident energy and arc flash boundary calculations

1.4 SUBMITTALS

A. Qualifications Data: Submit the following for review prior to starting study.

1. Submit qualifications and background of firm.

2. Submit qualifications of Professional Engineer performing study.

B. Software: Submit for review information on software proposed to be used in performing study.

C. Product Data: Submit the following:

1. Report: Summarize results of study in report format including the following:

a. Descriptions, purpose, basis, and scope of study.

b. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short-circuit duties, and commentary regarding same.

c. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip settings, fuse selection, and commentary regarding same.

d. Fault current calculations including definition of terms and guide for interpretation of computer printout.

e. Furnish an Arc Flash Hazard Analysis Study per NFPA 70E & IEEE 1584 - Standard for Electrical Safety in the Workplace, reference Article 130.5 and Informative Annex D.

D. Submit copies of final report signed by Professional Engineer. Make additions or changes required by review comments.

E. Short Circuit Study:

1. Systematically calculate the fault impedance to determine the available short circuit and ground fault currents at each bus. Incorporate the motor contribution in determining the momentary and interrupting ratings of the protective devices.

2. Entire system shall be modeled under both normal and emergency power. If any closed transition transfer switches are used, normal and emergency power shall be combined.

3. The short circuit study shall incorporate the actual feeder types, sizes and lengths proposed to be used by the Professional Engineer.

4. The calculations may be prepared by means of a digital computer. All pertinent data and the rationale employed in developing the calculations shall be incorporated in the introductory remarks of the study.

5. Present the data determined by the short circuit study in a table format. Include the following:

    a. Device identification.

    b. Operating voltage.

    c. Protective device.

    d. Device rating.

    e. Calculated short circuit current, indicating worst-case fault current incorporating all system models as outlined above.

F. Coordination Curves:

1. Prepare the coordination curves to determine the required settings of protective devices to assure selective coordination. Graphically illustrate on log-log paper that adequate time separation exists (where possible) between series devices, including the utility company upstream device. Plot the specific time-current characteristics of each protective device in such a manner that all upstream devices will be clearly depicted on one sheet. Where a switchboard or panelboard has multiple devices of different sizes, it is not necessary to plot curves for each device when coordination for one device is demonstrated graphically and it is intuitively obvious that the other devices coordinate as well.

2. The following specific information shall also be shown on the coordination curves:

    a. Device identification.

    b. Voltage and current ratio for curves.

    c. 3-phase and 1-phase ANSI damage points for each transformer.

d. No-damage, melting, and clearing curves for fuses.

e. Cable damage curves.

f. Transformer inrush points.

g. Maximum short circuit cutoff point.

h. Short-time withstand capability of main 480V circuit breakers.

i. Coordination between the directional overcurrent relays and the main 480V breaker.

3. Develop a table to summarize the settings selected for the protective devices. Include in the table the following:

a. Device identification.

b. Relay CT ratios, tap, time dial, and instantaneous pickup.

c. Circuit breaker sensor rating, long-time, short-time, and instantaneous settings, and time bands.

d. Fuse rating and type.

e. Ground fault pickup and time delay.

G. ARC FLASH HAZARD ANALYSIS

1. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2015, Informative Annex D.

2. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short circuit and coordination study model. Alternative methods shall be presented in the proposal.

3. The arc flash boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where work could be performed on energized parts.

4. The Arc-Flash Hazard Analysis shall include all MV, 575v, & 480v locations and significant locations in 240 volt and 208 volt systems fed from transformers equal to or greater than 125 kVA.

5. Safe working distances shall be specified for calculated fault locations based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm$^2$.

6. The Arc Flash Hazard analysis shall include calculations for maximum and minimum contributions of fault current magnitude. The minimum calculation shall assume that the

utility contribution is at a minimum and shall assume a minimum motor load. Conversely, the maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

7. Arc flash computation shall include both line and load side of main breaker calculations, where necessary.

8. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section B.1.2.

9. Incident energy and arc flash boundary calculations.

   a. Arcing fault magnitude

   b. Device clearing time

   c. Duration of arc

   d. Arc flash boundary

   e. Working distance

   f. Incident energy

   g. Recommendations for arc flash energy reduction including the use of arc reduction maintenance switches, replacement of overcurrent protective devices and/or trip units, or replacement of equipment with arc resistant or preventative designs. The Engineering Services Organization shall provide a turnkey proposal for implementing the arc flash reduction strategies.

## 1.5 QUALITY ASSURANCE

A. Maintain one copy of each document on site.

B. Use commercially available software, designed specifically for short circuit and protective device coordination studies with minimum of three years documented availability approved by LAWA.

C. Perform study in accordance with IEEE 242.

## 1.6 QUALIFICATIONS

A. Study Preparer: Company specializing in performing work of this section with minimum five years documented experience and having completed projects of similar size and complexity within the past three years.

B. Perform study under direct supervision of Professional Engineer experienced in design of this Work and licensed at in State of California with minimum of five years experience in power system analysis.

C. Demonstrate company performing study has capability and experience to provide assistance

during system start up.

1.7 SEQUENCING

A. The short circuit portion of the study shall be submitted prior to or along with the switchgear submittal, and shall include all equipment which has an AIC rating. The short circuit study shall reflect that all equipment with an AIC rating is properly rated for its specific application. The submitted switchgear (including all equipment which has an AIC rating) shall reflect the findings of short circuit study (i.e., the AIC ratings of the equipment shall exceed the available short circuit current and any required derating factors at each point in the system.). No series rated devices will be allowed.

B. When formal completion of study will cause delay in equipment manufacturing, obtain approval from LAWA for preliminary submittal of study data sufficient in scope to ensure selection of device ratings and characteristics will be satisfactory.

1.8 SCHEDULING

A. Schedule work to expedite collection of data to ensure completion of study for final approval of distribution equipment shop drawings prior to release of equipment for manufacturing.

1.9 COORDINATION

A. Coordinate work with local power company.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Provide assistance to electrical distribution system equipment manufacturer during start up of electrical system and equipment.

B. Select each primary protective device for delta-wye connected transformer so devices characteristic or operating band is within transformer characteristics, including point equal to 58 percent of ANSI withstand point to provide secondary line-to-ground fault protection.

C. Separate transformer primary protective device characteristic curves from associated secondary device characteristics by 16 percent current margin to provide proper coordination and protection in event of secondary line-to-line faults.

D. Separate medium-voltage relay characteristic curves from curves for other devices by at least 0.4

second time margin.

E. Analyze the short circuit calculations, and highlight any equipment that is determined to be underrated as specified. Propose approaches to effectively protect the underrated equipment. Provide minor modifications to conform with the study (Examples of minor modifications are trip sizes within the same frame, the time curve characteristics of induction relays, CT ranges, etc.).

F. After developing the coordination curves, highlight areas lacking coordination. Present a technical valuation with a discussion of the logical compromises for best coordination.

## 3.2 ADJUSTING

A. Protective devices shall be set based on the results of the protective device coordination study.

B. Arc fault hazard analysis warning labels shall be printed and affixed to the electrical system equipment after the final protective relay settings have been applied and confirmed operational.

C. Settings and adjustments of the relays shall be performed by and independent qualified agency familiar with this work and the agency is to be retained by the contractor. The person performing this work shall have a minimum of five years experience.

D. Accomplish necessary field settings, adjustments, and minor modifications to conform with the study without cost to LAWA.

## 3.3 ARC FLASH WARNING LABELS

A. The vendor shall provide a 4 in. x 4 in. thermal transfer type label of high adhesion polyester for each work location analyzed.

B. The label shall have an orange header with the wording, “WARNING, SHOCK & ARC FLASH HAZARD”, and shall include the following information:

1. Location designation
2. Nominal voltage
3. Arc flash boundary
4. Incident energy
5. Working distance
6. Shock Boundaries
7. Engineering report number, revision number and issue date
8. Labels shall be machine printed, with no field markings
9. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.

10. For each 600, 480 and applicable 208 volt panelboards and disconnects, one arc flash label shall be provided
11. For each motor control center, one arc flash label shall be provided
12. For each low voltage switchboard, one arc flash label shall be provided
13. For each switchgear, one flash label shall be provided
14. For medium voltage switches one arc flash label shall be provided
15. Labels shall be field installed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

3.4 ARC FLASH TRAINING

A. The equipment vendor shall train personnel of the potential arc flash hazards associated with working on energized equipment (minimum of 4 hours). Maintenance procedures in accordance with the requirements of NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces, shall be provided in the equipment manuals. The training shall be certified for continuing education units (CEUs) by the International Association for Continuing Education Training (IACET).

END OF SECTION

# SECTION 26 07 00
# TESTING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. This section describes the requirements of the following work necessary to complete the testing required for the item specified under this Division, including but not limited to:

1. Testing Company: The following testing shall be performed by an independent testing company on all new equipment:

   a. Service Grounding Test

   b. Ground Fault Protection Systems Test & Calibration

   c. Transformers, Dry Type

   d. Motor Controls

   e. Switchboards

   f. Circuit Breaker Tests

   g. Metering Test and Calibration

   h. Busway (refer to Section 26 2500)

   i. UPS (refer to Section 26 3353)

2. Contractor Testing: The following testing shall be performed by the contractor:

   a. Fire Alarm Systems (refer to Section 28 3100)

   b. Receptacle and Device Tests

   c. 600 volt wiring

   d. Power System Tests

e. Variable Frequency Drives

f. Fan Shutdown Systems

g. Smoke Damper Control

h. Lighting Control System

B. Related work: Consult all other Sections, determine the extent and character of related work and properly coordinate work specified herein with work specified elsewhere to perform a complete testing.

C. Description of work: Test and provide written certification that the entire electrical installation complies with contract documents, code and proper system operation. Perform acceptance tests in accordance with manufacturer's recommendations, NFPA 70B and International Electrical Testing Association (NETA) testing specifications NETA ATS-1999.

1.3 SUBMITTALS

A. Submit in accordance with Division 01 Section Submittals Procedures, Closeout Procedures and Project Record Documents.

B. General:

1. The results of the tests shall be summarized in a final report. Test Reports shall be typewritten and submitted to the Owner's Representative within 7 calendar days of the test.

2. The Contractor shall prepare test reports including description of project, description of equipment tested, description of test, test results, conclusions and recommendations, re-testing results and list of test equipment used and calibration date.

3. Notify the Owner's Representative in writing 10 working days prior to performance of any test.

4. Insert a copy of each test report in the operation and maintenance manuals

C. Preliminary testing Submittal: Prior to commencement of testing, the testing firm shall submit the following:

1. List of equipment to be tested and testing schedule, including staffing and equipment

2. Test procedures to be used in a complete summarized format. Tests shall include:

a. Tests specified in this section and all individual Division 26 sections.

b. Manufacturer's recommendations for maintenance and acceptance testing, including inspections and measurements.

c. Copies of maintenance manual sections describing manufacturer's recommended procedures.

3. Proposed test data sheets.

4. Proposed test equipment list.

D. Test Reports

1. Progress Reports: Provide 3 copies of test data sheets as major equipment tests are performed, or whenever defective equipment is discovered.

2. Final Report: Submit a final typed report at the completion of the project testing/startup scope. The report shall include:

a. Summary of the project

b. Description of equipment tested

c. Data sheets

d. Description of test procedures

e. Conclusions and deficiencies

E. Perform all testing after installation. All systems shall pass tests prior to substantial completion or occupancy.

1.4 QUALITY ASSURANCE

A. Qualifications of Testing Company

1. The testing firm shall be an independent testing organization that can function as an unbiased testing authority, professionally independent of the manufacturer's, suppliers, and installers of equipment or systems evaluated by the testing firm.

2. The testing firm shall meet the criteria for Full Membership or be a Full Member company of the InterNational Electrical Testing Association (NETA).

3. A minimum of ten (10) years experience in testing electrical equipment is required for the individual in charge of the project.

4. The firm performing the study should demonstrate capability and experience to provide assistance during start up as required.

5. Personnel

   a. The testing firm shall only utilize full-time engineers who are regularly employed by the firm for testing services.

   b. All on-site personnel shall have a minimum of 5 years of experience in electrical equipment startup and testing.

   c. The firm shall provide a competent project engineer to oversee and coordinate all site work, and shall be on site whenever 3 or more of the firm's engineers are on site.

B. Test Instrument

1. Utilize a calibration program that assures that all applicable test instruments are maintained within rated accuracy.

2. Accuracy directly traceable to the National Institute of Standards and Technology

3. Calibrate instruments in accordance with the following frequency schedule:

   a. Field Instruments: Analog - 6 months maximum; Digital - 12 months maximum

   b. Laboratory Instruments: 12 months

   c. Leased Specialty Equipment: 12 months (Where accuracy is guaranteed by leaser)

4. Maintain dated calibration labels visible on all test equipment.

5. Keep records that show date and results of instruments calibrated or tested up-to-date.

6. Maintain up-to-date instrument calibration instructions and procedures.

C. Comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:

1. NFPA 70 – California Electrical Code (CEC)

2. IEEE Standard 81 - Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Parts 1 & 2)

3. IEEE Standard 141 - Recommended Practice for Electrical Power Distribution for Industrial Plants

4. IEEE Standard 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.

5. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment & Systems.

1.5 TESTS TO BE PERFORMED BY TESTING COMPANY

A. Service Grounding Test:

1. Perform fall-of-potential tests on main grounding electrode system provided by this contract per IEEE Standard No. 81. Maximum resistance to ground shall be less than 5 ohms. If this resistance cannot be obtained with the ground system shown, notify the Owner's Representative immediately for further instructions.

2. Confirm that the neutral is grounded only at the service equipment by removing the service neutral grounding conductor and meggering the neutral bus.

3. Refer to Grounding section for additional testing and requirements.

B. Ground Fault Protection Systems Tests:

1. Scope: Test all ground fault protection systems provided by this contract.

2. Prior to Test:

a. Inspect neutral main bonding connection to assure:

1) Zero sequence system is grounded upstream of sensor

2) Ground connection is made ahead of neutral disconnect link

3) Ground strap systems are grounded through sensing device

4) Verify ground electrode conductor(s) for proper size and connection

b. Inspect control power transformer to insure adequate capacity for system

c. Monitor panels (if present) shall be manually operated for:

1) Trip test

2) No trip test

3) Non-automatic reset

d. Proper operation and test sequence shall be recorded.

e. Zero sequence systems shall be inspected for symmetrical alignment of core balance transformers about all current carrying conductors.

f. Ground fault system integral to the circuit breaker will have its current sensors and neutral sensor inspected for proper polarity.

g. Ground fault device circuit nameplate identification shall be verified by device operation.

h. Pickup and time delay settings shall be set in accordance with engineer's instructions or as shown.

3. Electrical Test:

a. System neutral insulation resistance shall be measured to insure no shunt ground paths exist, neutral-ground disconnect link shall be removed, neutral insulation resistance measured and link replaced.

b. The relay pickup current shall be determined by current injection at the sensor and the circuit interrupting device operated.

c. The relay timing shall be tested by injecting 150% and 300% of pickup current into sensor. Total trip time shall be electrically monitored.

d. System operation shall be tested at 57% rated voltage.

e. Zone interlock system shall be tested by simultaneous sensor current injection and monitoring zone blocking function.

4. Test Parameters:

a. System neutral insulation resistance shall be two (2) mega-ohm or greater.

b. Relay pickup current shall be within 10% of device dial of fixed setting.

c. Relay timing shall be in accordance with manufacturer's published time-current characteristic curves.

C. Transformers, Dry Type:

1. Test dry type transformers provided by this contract.

2. Visual and Mechanical Inspection: Test dry type transformers per the following procedures:

a. Inspect for physical damage, proper installation, anchorage and grounding.

b. Verify transformer is supplied and connected in accordance with contract documents.

3. Electrical Tests: Perform insulation resistance tests winding-to-winding and winding-to-ground.

D. Motor Controls:

1. Test motor control centers provided under this contract.

2. Visual and Mechanical Inspection

a. Inspect for physical damage and code violation.

b. Inspect for support and grounding.

c. Compare equipment nameplate data with design plans or starter schedule.

d. Check tightness of bolted connections.

e. Compare overload heaters with motor full load current.

f. Compare starter size with motor horsepower.

g. Verify that correct heaters are installed in overload relays.

h. Inspect power factor correction capacitors for complete connections and operation.

3. Electrical Tests

a. Measure overload time delay by primary current injection at three (3) times motor full load current.

b. Perform operational tests on each starter.

E. Circuit Breakers:

1. Scope: Test all circuit breakers 100 amps and over within new switchboards, panelboards and enclosures.

2. Inspect each breaker, operate manually, and electrically. Test shunt trips and alarm devices manually and electrically.

3. Adjust breaker trips to settings provided by the coordination study and verify settings of the manufacturer's rating by passing controlled current through the trip devices. Record values and report deficiencies.

4. Circuit Breaker Electrical Tests

a. Contact resistance shall be measured.

b. Time-current characteristic tests shall be performed by passing 300% rated current through each pole separately. Trip time shall be determined.

c. Instantaneous pickup current shall be determined by run-up or pulse method. Clearing times should be within four (4) cycles or less.

d. Insulation resistance shall be determined pole-to-pole, across pole and pole-to-ground, and across open contacts. Test voltage shall be 1000 volts dc for breakers rated greater than 250 volts. Test voltage shall be 500 volts dc for breakers rated 250 volt or less.

e. Check trip unit reset operation.

F. Switchboards:

1. Scope: Test all new switchboards and test all new breakers, installed in switchboards and distribution panelboards.

2. Inspect equipment and each breaker, fused switch and report installation or shipping damage, loose material, shipping blocks, contamination or unfavorable environmental conditions that must be corrected. Check equipment for operation of doors, security of mounting. Report any deficiencies.

3. Check the equipment ground and record the number and size or ground bus and straps. Report any deficiencies.

4. Inspect the bus assembly for deficiencies and torque test all bolted connections. Test insulation of each bus phase-to-phase and phase-to-ground and all control circuits to ground with a suitable megohmmeter. Record values and report deficiencies.

5. Inspect for proper identification of protective devices.

6. Surge Arrestors: Test surge arrestors per the following procedures:

a. Visual and Mechanical Inspection

1) Inspect for physical damage, such as chipped or fractured porcelain.

2) Inspect ground and discharge counter connections for integrity.

b. Electrical Tests

1) Perform ground continuity test to ground grid system.

G. Metering Test & Calibration for Meters

1. Scope: Test all new meters provided by this contract.

2. Instrument Transformers

   a. Test transformer polarity electrically.

   b. Verify connection at secondary CT leads by driving a low current through the leads and checking for this amount at applicable devices.

   c. Confirm transformer ratio by primary current injection.

   d. Measure insulation resistance primary-to-ground, secondary-to-ground and primary-to-secondary.

   e. Over potential test primary insulation.

   f. Measure potential transformer ratio.

3. Metering and Instrumentation

   a. Calibrate all meters at mid-scale.

   b. Calibrate watt hour meter to one-half percent.

   c. Verify all instrument multipliers.

## 1.6 TESTS TO BE PERFORMED BY CONTRACTOR

A. Receptacle and Device Tests

1. Receptacle Polarity Test: Test every receptacle installed or reconnected under this contract with a receptacle circuit tester. Tester shall test for open ground, reverse polarity, open hot, open neutral, hot and ground reversed, hot or neutral and hot open. Rewire receptacles with faults and re-test. Submit test report signed by the electrician that performed the test.

2. Ground-Fault Receptacle Circuit Interrupter Tests: Test each receptacle or branch circuit breaker having ground-fault circuit protection to assure that the ground-fault circuit interrupter will not operate when subjected to a ground-fault current of less than 4 milliamperes and will operate when subjected to a ground-fault current exceeding 6 milliamperes. Perform testing using an instrument specifically designed and manufactured for testing ground-fault circuit interrupters. Apply the test to the receptacle. A TEST @ button operation will not be acceptable as a substitute for this test. Replace receptacles that do not shut-off power with 5/1000 of an ampere with 1/40th of a second and re-test.

3. Operational Tests: Demonstrate the operation of each switch, circuit breaker and other item of electrical control with the systems fully energized and operating. Each shall be demonstrated 3 times.

B. 600 Volt Wiring

1. Scope: Test all electrical feeders and conductors for motors over 15 hp whose operating voltage is 600 volts or less that are installed or re-connected under this contract.

2. Test for continuity of each circuit.

3. Test for grounds in each circuit which shall consist of the physical examination of the installation to ensure that all required ground jumpers, devices, and appurtenances do exist and are mechanically firm.

4. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Test duration shall be 1 minute. If conductor fails test replace wiring or correct defect and re-test.

5. Perform torque test for each conductor tested and terminated in an over current device or bolted type connection; torque all connections per manufacturer's recommendations and tabulate the results on a tabular form.

6. All feeders shall be Megger tested prior to energizing any equipment.

C. Power System Tests

1. Scope: Inspect and test entire electrical systems provided by this contract to verify equipment and controls are correctly operating.

2. Load Balance Tests: Check all panelboards for proper load balance between phase conductors and make adjustments as necessary to bring unbalanced phases to within 15% of average load.

3. Motor Tests: Prior to energizing any motors check all motors for proper rotation, phase balance and measure actual load current. Report immediately to the Owner's Representative if phase balance exceeds 1% from mean value. Submit tabulation of motor currents for all motors 1 HP or more after the HVAC system has been balanced.

4. Phase Relationship Tests: Check connections to all new and existing equipment for proper phase relationship. During such check, disconnect all devices that could be damaged by the application of voltage or reversed phase sequence.

5. Transformer Taps: Connect all transformers at A Normal @ tap. After facility is fully occupied for a period of not less than two weeks, measure secondary voltages at all new and existing transformers

D. VARIABLE FREQUENCY DRIVES

1. Physical and Mechanical Inspection (Electrical Contractor)

   a. Drive and motor environment clean.

   b. Adequate drive and motor access for ventilation and maintenance

   c. No unusual noise or vibration.

   d. No disconnects installed between VFD and motor without shutdown interlock to VFD.

   e. Shut-down interlocks between VFD and motor verified to be operational.

   f. Separate conduit for incoming power and outgoing motor leads.

   g. No power factor correction capacitors connected to motor.

   h. Shaft rotation correct, normal operation

   i. If equipped with bypass, note bypass starter overload size for correct operation.

   j. Shaft rotation correct for bypass operation.

   k. Verify bypass switch starts and operates equipment.

   l. Compare motor nameplate with VFD for compatibility.

   m. Inspect structure frames, supports, barriers, doors, hinges, etc. for alignment and proper fit.

   n. Inspect control wiring terminations, fuses, shielding, pull apart connectors, and board engagement.

2. Electrical Checks (Electrical Contractor)

   a. Verify wiring conforms to factory schematics.

   b. Verify instrument transformer ratios match meter scales.

3. Electrical Checks (Manufacturer’s Representatives)

   a. Insure proper operation of:

      1) Pilot devices (switches, pushbuttons, lights)

2) Contactors and line voltage starters.

3) Control and timing relays.

4) Protective devices.

5) Auxiliary electrical contacts.

6) Circuit breakers and disconnect switches.

b. Perform other tests and startup procedures as recommended by manufacturer.

## PART 2 - PRODUCTS

### 2.1 TESTING COMPANY

A. Retain the services of an independent testing company that is qualified to test electrical equipment, and is an approved testing company by the State of California. The testing company shall not be associated with the manufacturer of equipment or systems under test. The testing company shall be Electro-Test Inc. (ETI), Applied Engineering Concepts (AEC), or equal.

B. Testing company shall prepare typewritten reports on all the systems they test.

### 2.2 TEST EQUIPMENT

A. The contractor shall provide all apparatus and material required for testing. The Contractor shall use installation tools and test equipment that are designed for the specific task and shall use this equipment per the manufacturer's instructions.

B. All test equipment shall have current calibration certification by a third party calibration laboratory, and shall have a signed and dated calibration sticker affixed to the device. Calibration shall be traceable to the National Bureau of Standards and shall not be less than 6 months since last calibration. Defective test equipment and installation tools shall not be used. Installation tools such as torque wrenches shall be calibration certified.

## PART 3 - EXECUTION

### 3.1 PROJECT DOCUMENTS

A. Deliver the following project documents to testing company two weeks prior to testing:

1. Division 26 Specifications

2. Electrical Floor Plans showing equipment to be tested

3. Electrical One-Line Diagrams

4. Submittals of Manufacturer's Data and Shop Drawings including engineers review letter of all systems to be tested.

5. Short Circuit and Coordination Study

3.2 RE-TESTING

A. Any fault in material or in any part of the installation revealed by these tests shall be investigated, replaced or repaired by the Contractor and the same test repeated at the Contractor's expense until no fault appears.

3.3 LABELS

A. Upon completion of testing agency tests a NETA label shall be attached to all serviced devices. These labels shall indicate date serviced and the testing company.

3.4 TROUBLESHOOTING

A. If a system or device provided under this contract does not operate per manufacturer's specifications, Contractor shall provide qualified men with tools and test equipment to find and repair problem at contractor's expense.

END OF SECTION

# SECTION 26 09 13
# WEB-BASED POWER MONITORING COMMUNICATIONS SYSTEM

## PART 1 - GENERAL

### 1.1 SUMMARY

A. This section describes the metering, communications, and visualization requirements for a modular, scalable Web-based Power Monitoring Communications System. The goal of this system is to provide the user the ability to monitor and manage their power system without the installation of any software other than an internet browser. This system may require the user to store web links in their browser to each of the web enabled devices; however the intent of this approach is to significantly reduce installation, configuration and operational costs of the system.

1. The PMCS shall comply with new construction installations utilizing web-based components to function independently or to co-exist with other Eaton Cutler-Hammer IMPACC system components or other Modbus RTU communicating devices in a heterogeneous environment.

2. For compatibility purposes, all new web based power monitoring systems shall match the installation at Bradley West.

B. This section includes the supply and installation of a complete Power Monitoring Communications System (PMCS) as described in this specification. The PMCS is defined to include, but not to be limited to, remote devices for metering, monitoring, control and protection, a network time server, all Ethernet communications gateways, intercommunication wiring, ancillary equipment, startup and training services, and ongoing technical support.

C. All Tenant power feeders are to be metered by this system.

### 1.2 SUBMITTALS – FOR REVIEW/APPROVAL

A. The following information shall be submitted to the Engineer:

1. System description including an overview of the system provided with detailed description of system architecture. A customized system diagram showing location of computers, repeaters, gateways and assemblies/devices to be connected to the system, as well as types of wiring required (twisted pair, coax, fiber), and a general layout of wiring referencing the specific building/facility layout shall also be part of this description.

2. Bill of material including a complete listing of all hardware, software, training, software configuration, and startup services.

3. Hardware and software description shall be provided in detail for all communications hardware, software, including sensor devices and gathering data to be transmitted over the network, and master display unit. This description will include a list of all the communicating devices to be connected to the network.

4. Typical software screen displays shall be provided in printout form and/or on disk.

1.3 SUBMITTALS – FOR INFORMATION

A. The Contractor shall provide a submittal for information to include a detailed listing of customer required actions, with timetable, to insure trouble-free startup of the PMCS. This information shall include any equipment access requirement, office requirements and manpower requirements. This submittal shall include the projected system startup time-line, including training dates. In addition, a proposed detailed wiring specification in compliance with these plans and specifications shall be included. The communication wiring specification shall include proposed communication cable, including general cable ratings, communication characteristics, cable routing proposed, termination requirements, and splicing/connections proposed to be made.

1.4 SUBMITTALS – FOR CONSTRUCTION

A. In addition, the systems operation manual shall include the following information:

1. A system description overview, descriptive bulletins and/or sales aids covering all components in the system.

2. A maintenance section including all instruction leaflets and technical data necessary to set up, change setup parameters and maintain the communicating devices and sensors.

B. A section on communication wiring which includes:

1. Type of communication wire utilized.

2. General cable ratings and communications characteristics.

3. Cable routing diagram including terminations and splicing connections made.

C. A detailed startup report, including a list of trained customer personnel shall be provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Cutler-Hammer.

B. Square D.

C. General Electric.

## 2.2 GENERAL

A. The PMCS is defined to include, but not to be limited to, remote devices for metering, monitoring, control and protection, a network time server, all Ethernet communications gateways, intercommunication wiring, printer, ancillary equipment, startup and training services, and ongoing technical support.

## 2.3 WEB-ENABLED POWER MONITORING COMMUNICATION SYSTEM

A. The web-enabled power monitoring communication system shall use Ethernet as the primary communication backbone between the equipment and the users or legacy systems.

B. The web-enabled power monitoring communication system shall support multiple protocols over Ethernet to ensure the system can easily be integrated into existing systems. These protocols shall include:

1. HTML web pages to display data to users using a browser.

2. Modbus TCP/IP to support integration into third party systems.

3. BacNet Web Services to support integration into third party systems.

4. SNMP to support integration into Data Center management systems.

C. The web enabled power monitoring communication system shall provide connectivity to the actual power system in one of two ways:

1. Web enabled meters that measure the critical power system parameters as described herein.

2. Web enabled gateways that communicate to power system devices over device specific communication links as described herein. Web enabled gateways will support the following device communication protocols:

a. Eaton’s INCOM protocol.

b. ModBus RTU over RS-485.

c. Eaton’s QC Port over RS-485.

3. The web enabled gateway shall support devices as required.

4. The devices connected to the Web enabled gateway shall communicate using the protocols described in Section 2.03 F2 over a local area network Interconnected with #18 gauge twisted pair shielded cable, 600 V Class Belden 9463 family, in properly sized conduit (when run outside of factory assembled equipment for the communication channel).

D. The web enabled power monitoring communication system shall provide support for configuration of all web enabled meters and gateways directly via the web pages on the device. No additional software shall be required. To support the configuration of legacy devices on the device networks connected to the gateway, the gateway shall support a "pass thru mode" to allow the legacy configuration software to connect from any computer on the users network to the device via the gateway.

E. All devices in the web enabled power monitoring communication system that are connected directly to Ethernet shall support the ability to synchronize their time clock using NTP. The purpose for this support is to ensure all device clocks are accurate so that event sequences can be adequately analyzed.

1. For devices that support clock synchronization and are on the device networks connected to the gateways, they shall support the ability to sync their clock to the clock in the gateway.

F. A User Guide shall be provided with the web enabled equipment to describe the commissioning process for setting the equipment's Ethernet address, and ensuring trouble- free data access from any computer on the network, using a standard Internet browser.

G. In all web enable devices, a common user interface shall be implemented across all types of power equipment, from Medium-Voltage Switchgear to Low-Voltage Switchgear, Switchboards, Motor Control Centers (MCCs), Power Distribution Units (PDUs) and Uninterruptible Power Supplies (UPSs). The purpose of this is to reduce end user training time and improve system usability.

## 2.4 ETHERNET SWITCHES

A. A single web access point: 4 or 6 port Ethernet switch shall be provided in the equipment to allow a single access point for the user and the ability to connect more than one network device directly on the customer's Ethernet Local Area Network (LAN).

B. Ethernet switch shall support standard copper RJ45 connectors and/or 100BaseFX Fiber- Optic via ST connectors.

C. All switches are subject to the approval of the LAWA IMTG.

# PART 3 - EXECUTION

## 3.1 WARRANTY

A. The manufacturer shall warrant the equipment supplied hereunder. The warranty shall include:

1. Two (2) year free telephone technical support.

2. Warranty on all hardware supplied under this system shall be for two (2) years.

3.2 FACTORY TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section.

1. Configure and load all software.

2. Test and operate computer and software in a simulated system mode for a minimum of 24 hours.

3. Demonstrate full system functionality.

3.3 INSTALLATION

A. The Contractor shall furnish, install and terminate all communication conductors and associated conduits external to any factory supplied equipment.

B. All communication conductor wiring and routing shall be per the manufacturer's recommendations.

3.4 FIELD QUALITY CONTROL

A. The contractor shall furnish the services of a manufacturer's representative to assist LAWA in starting up and programming the system. The manufacturer's representative shall be factory-trained and shall have a thorough knowledge of the software, hardware, and system programming. The manufacturer's representative shall provide the following services:

1. Setting all the addresses of all devices in the equipment.

2. Verifying and troubleshooting the integrity of the data line (run by others).

3. Assisting LAWA in correcting any data line problems.

4. Coordinating any possible warranty problems with the PMCS.

5. Configure the PMCS software to match the field devices.

3.5 FIELD TESTING

A. Verify complete system operation including all hardware, software and communication devices.

B. Verify networking performance with all interfacing systems by other manufacturers.

## 3.6 MANUFACTURER'S CERTIFICATION

A. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.

B. The Contractor shall provide five (5) copies of the manufacturer's representative's certification.

## 3.7 TRAINING

A. The Contractor shall furnish the services of a manufacturer's representative for a period of one (1) 8-hour days to train the LAWA's personnel in operation and programming of the system. The manufacturer's representative shall be factory-trained and shall have a thorough knowledge of the software, hardware and system programming. The training session shall include:

1. Hands-on training of site personnel.

2. Explanation of system operation.

3. Explanation of devices.

4. Explanation of LAWA's system.

## 3.8 AFTER STARTUP SUPPORT

A. The PMCS manufacturer shall provide a 24-hour 800 telephone number manned with Engineers/Technicians expert in PMCS devices, software and communication system troubleshooting or capable of providing technical information.

B. The PMCS Manufacturer shall provide a 1 year service contract to maintain the software and system devices. The contract shall be renewable on an annual basis at a fixed charge and shall include a minimum of 2 site visits yearly to perform system maintenance. The service contract shall include as a minimum:

1. Installation of Software patches and Upgrades to System Operating Software as required.

2. Anti-Virus Software upgrades as required.

3. PMCS Software upgrades as required.

4. Database maintenance and archiving of data.

END OF SECTION

# SECTION 26 09 23
# LIGHTING CONTROL DEVICES AND CONTROL PANELS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Remote control lighting relays.
2. Lighting contactors.
3. Switches.
4. Switch plates.
5. Occupancy sensors.
6. Photocells.
7. Photocell control unit.

### 1.2 SYSTEM DESCRIPTION

A. The devices are to be connected to the Network Lighting Control System.

B. Distributed switching control using self-contained individually mounted lighting relays.

### 1.3 SUBMITTALS

A. Shop Drawings: Indicate dimensioned drawings of lighting control system components and accessories.

1. Wiring Diagram: Indicating system configuration indicating panels, number and type of switches or devices.
2. Include typical wiring diagrams for each component.

B. Product Data: Submit manufacturer’s standard product data for each system component.

### 1.4 WARRANTY

A. Furnish five year manufacturer warranty for components.

PART 2 - PRODUCTS

2.1 REMOTE CONTROL LIGHTING RELAYS

A. Manufacturers:

1. LC & D.

2. Lutron.

3. General Electric.

B. Product Description: Heavy duty, single-coil momentary contact mechanically held remote control relays.

C. Contacts: Rated 20 amperes at 120 or 277 volts. Rated for lighting applications with high intensity discharge (HID), quartz halogen, tungsten, or fluorescent lamps.

D. Line Voltage Connections: Clamp type screw terminals.

E. Enclosure: NEMA ICS 6, to meet conditions. Fabricate enclosure from steel finished with manufacturer's standard gray enamel.

1. Interior Dry Location: Type 1

2. Exterior Locations: Type 4

2.2 LIGHTING CONTACTORS

A. Manufacturers:

1. Cutler-Hammer.

2. Square D.

3. General Electric.

B. Product Description: NEMA ICS 2, magnetic lighting contactor.

C. Configuration: Mechanical held, 3 wire control.

D. Coil Operating Voltage: 120 or 277 volts, 60 Hertz.

E. Poles: To match circuit configuration and control function.

F. Contact Rating: 20A

G. Accessories:

1. Cover Mounted Pilot Devices: NEMA ICS 5, standard-duty heavy-duty oil-tight type with Form Z contacts, rated A150.

2. Pushbutton: ON/OFF function, with unguarded recessed covered configuration.

3. Selector Switch: ON/OFF/AUTOMATIC functions, with rotary action.

4. Auxiliary Contacts: One field convertible in addition to seal-in contact.

5. Relays: NEMA ICS 2

6. Control Power Transformers: 120 volt secondary, in each enclosed contactor. Furnish fuse primary and secondary, and bond unfused leg of secondary to enclosure.

H. Enclosure: NEMA ICS 6, to meet conditions. Fabricate enclosure from steel finished with manufacturer's standard gray enamel.

1. Interior Dry Location: Type 1.

2. Exterior Locations: Type 4.

## 2.3 SWITCHES

A. Manufacturers:

1. Hubbell Incorporated.

2. Leviton Manufacturing Co., Inc.

3. Pass and Seymour.

B. Wall Switch: Specification Grade unlighted, momentary pushbutton type for overriding relays.

1. Material: Plastic.

2. Color: White.

C. Wall Switch: Industrial Grade non-pilot light toggle switches for overriding relays.

1. Color: White

D. Key Switch: Cylinder lock type. Match non-key switch rating.

## 2.4 SWITCH PLATES

A. Manufacturers:

1. Hubbel Incorporated.

2. Leviton Manufacturing Co., Inc.

3. Pass and Seymour.

B. Product Description: Specification Grade.

1. Material: Stainless steel, type 302.

2. Color: to be selected by Designer.

2.5 OCCUPANCY SENSOR

A. Manufacturers:

1. LC & D.

2. Novitas.

3. Watt Stopper.

B. Compatible with modular relay panels. Capable of being wired directly to Class 2 wiring without auxiliary components or devices.

C. Separate sensitivity and time delay adjustments with LED indication of sensed movement. User adjustable time-delay: 30 seconds to 12 minutes.

D. Furnish with manual override.

E. Operation: Silent.

F. Room Sensors: Dual Technology. G. Corridor and Hallway Sensors:

1. Capable of detecting motion 14 feet wide and 80 feet long with one sensor mounted 10 feet above floor.

2. Capable of detecting motion in warehouse aisle 10 feet wide and 60 feet long or 100 feet long when mounted 22 feet above floor.

3. Capable of being wired in master-slave configuration to extend area of coverage.

2.6 PHOTOCELLS

A. Manufacturers:

1. LC & D.

2. Novitas.

3. Watt Stopper.

B. General: Consist of sensor mounted with separate control-calibration module. Sensor connected to control-calibration module via single shielded conductor with maximum distance of 500 feet (150 m).

C. Control-Calibration Module: Furnish with the following:

1. Capable of being switched between 4 measurement ranges.

2. Separate trip points for high and low response settings.

3. Momentary contact device to override photocell relays.

4. Three minute time delay between switching outputs to avoid nuisance tripping.

D. Sensor Devices: Each sensor employs photo diode technology to allow linear response to daylight within illuminance range.

1. Exterior Lighting: Hooded sensor, horizontally mounted, employing flat lens, and working range 1-10 foot-candles in 10 percent increments. Entire sensor encased in optically clear epoxy resin.

2. Indoor Lighting: Sensor with Fresnel lens providing for 60 degree cone shaped response area to monitor indoor office lighting levels.

3. Atriums: Sensor with translucent dome with 180 degree field of view and respond in range of 100-1,000 foot-candles.

4. Skylights: Sensor with translucent dome with 180 degree field of view and respond in range of 1,000-10,000 foot-candles.

## 2.7 PHOTOCELL CONTROL UNIT

A. Manufacturers:

1. LC & D.

2. Novitas.

3. Watt Stopper.

B. Product Description: Photodiode control unit with PHOTOCELL ENABLE and MASTER OVERRIDE input for remote control, 3 minute time delay, and with selectable ranges for 1-10 foot-candle, 10-100 foot-candle, 100-1,000 foot-candle, and 1,000-10,000 foot-candle.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Mount switches, occupancy sensors, and photocells.

B. Use only properly color coded, stranded wire, installed in conduit.

C. Label each low voltage wire clearly indicating connecting relay panel.

D. Mount relays. Provide wiring to numbered relays in panel to control each load.

E. Install relays to be accessible. Allow space around relays for ventilation and circulation of air.

F. Identify power wiring with circuit breaker number controlling load. When multiple circuit breaker panels are feeding into relay panel, label wires to indicate originating panel designation.

G. Label each low voltage wire with relay number at each switch or sensor.

### 3.2 MANUFACTURER'S FIELD SERVICES

A. Furnish services for minimum of one day for check, test, and start-up. Perform the following services:

1. Check installation of panel boards.

2. Test operation of remote controlled devices.

3. Repair or replace defective components.

### 3.3 TRAINING

A. Demonstrate operation of the following system components to staff to be trained:

1. Operation of switches.

2. Operation of each type of occupancy sensors.

3. Operation of each type of photocell.

B. Furnish 4 hours to instruct LAWA's personnel in operation and maintenance of system.

Schedule training with LAWA, provide at least 7 days notice to Designer of training date.

C. Provide manuals for attendees.

END OF SECTION

# SECTION 26 09 43
# NETWORK LIGHTING CONTROL SYSTEM

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Provide a network lighting control system with the following features:

1. Distributed or centralized relay power pack and switching system.

2. Control provided by switches, photocells, occupancy sensors through relay packs and dimming control devices. Provide controls for discrete functions, dimming and scene presets.

3. Provide networking using Cat 5 cabling between devices and through bridging units, routers, and other network interface devices utilizing IP based addressability.

4. Allow user programming for each fixture and zone over a data network.

5. Provide all control software and programming.

6. Provide capability to control individual fixtures and zones from apps for user computers, tablets or smartphones.

7. Provide a system complying with Title 24 Energy Code requirements.

### 1.2 SUBMITTALS

A. Shop Drawings: Submit dimensioned drawings of lighting control system and accessories including, but not necessarily limited to, relay panels, switches, DTC, photocells and other interfaces.

B. Product Data: Submit for approval 6 copies of manufacturer's data on the specific lighting control system and components. Submittal shall be in both electronic and hard copy formats. To prevent departures from approved system operation, electronic file submitted shall be able to be directly downloaded to the specified system at manufacturer facility. Submit a complete bill of materials with part numbers, description and voltage specifications.

C. Wiring Diagram: Submit a Wiring diagram of the system configuration indicating the type, size and number of conductors between each component. Submittals that show typical riser diagrams are not acceptable. Provide completely filled out control schedules, switch engraving schedules and panel schedules.

### 1.3 QUALITY ASSURANCE

A. Manufacturers:

1. LC&D.

2. LUTRON

3. nLight.

B. Control wiring shall be in accordance with the NEC requirements for Class 2 remote control systems, Article 725 and manufacturer specification.

C. A licensed electrician shall functionally test each system component after installation, verify proper operation and confirm that all relay panel and switch wiring conform to the wiring documentation, and as per manufacturer recommendations.

D. Comply with NEC and all local and state codes as applicable to electrical wiring work.

E. Lighting control panels shall be ETL listed to UL 916. LCPs controlling emergency circuits shall be ETL listed to UL 924.

F. The lighting control system shall also be listed or approved by all national, state and local energy codes to include but not limited to California Title 24 and Los Angeles Building Code.

G. System shall have open software protocol to interface with BMS and central utility plant monitoring systems. Verify the BMS protocol required with LAWA. This protocol may involve providing a connection to the Central Utility Plant (CUP).

H. Specifications are based on LC&D system. Lutron or nLight shall comply with the compatibility and functionality to achieve the design intent.

## 1.4 MAINTENANCE MATERIALS

A. Execution Requirements: Spare parts and maintenance products.

B. Provide 8 spare relays per LCP, 4 Micro panels.

C. Provide extra CD version of manufacturers operating software to include graphical interface software.

D. Provide 2 extra sets of as-built and operating manuals.

# PART 2 – PRODUCTS

## 2.1 MATERIAL AND COMPONENTS

A. Provide devices required for complete integrated system.

1. NEMA rated enclosure with hinged door, available with main lug or main breaker and in voltages of 120/240, 208Y/120 and 480Y/277. Continuous main current ratings as indicated on the panelboard schedule. Minimum AIC rating to be 10,000. NEMA4 rating for outdoor installation.

2. Control electronics mounted internally to each smart panelboard shall be capable of driving up to 42 controllable breakers, control any individual or group of breakers, store all programming in non-volatile memory, after power is restored return system to current state, provide programmable blink warn timers for each breaker and every zone and be able to control a Micro Relay panel located downstream of non-controllable breaker.

3. Lighting control system shall be digital and consist of a Master LCP with up to 31 controllable, Slave LCPs with up to 42 controllable breakers in each panel, a Micro LCP with up to 4 individual relays, digital switches and digital interface cards (see interfaces). One individual bus network each for North Concourse + North Core and South Concourse + South Core. All system components shall connect and be controlled via a single Category 5, 4 twisted pair cable, providing real time two-way communication with each system component. Analog systems are not acceptable.

4. Lighting control system shall have the capability to output 4 independent 0V to 10V signals in a Micro LCP. Micro LCP shall control 4 independent 20a fluorescent lighting circuits. Each circuit shall have an adjustable fade rate and take inputs from a wall device, DTC system controller or a digital photocell.

5. Quantity and rating of breakers as required.

6. 16 AWG steel barrier shall separate the high voltage and low voltage compartments of the panel and separate 120V and 277V.

D. Controllable Breakers

1. Solenoid operated thermal magnetic breakers.

2. Ratings of 120/240 Vac; 15, 20 and 30 Amp; 1- and 2-pole, 277/480 Vac, 15, 20 and 30 amp: 1 and 2-Pole.

3. Rated at 20 Amp, 277 Vac Ballast, Tungsten, HID, 1 HP at 120 Vac, 2 HP at 240 Vac.

E. Standard Output Relays

1. Electrically held, electronically latched SPST relay.

2. Relays shall be individually replaceable. Relay terminal blocks shall be capable of accepting two #10AWG wires on both the line and the load side. Systems that do not

allow for individual relay replacement or additions are not acceptable.

3. Rated at 20 Amp, 277 Vac Ballast, Tungsten, HID, 1 HP at 120 Vac, 2 HP at 240 Vac.

4. Relays to be rated for 250,000 operations minimum at 20a lighting load, use Zero Cross circuitry and be Normally Closed (NCZC). All incandescent circuits shall be energized by use of a Normally Closed SoftStart™ (NCSS) relay rated at 100,000 operations at full 20a load. No exceptions.

5. Optional relay types available shall include: Normally Open (NO) relay rated for 100,000 operations, a 600V 2-pole NO and NC and a Single Pole, Double Throw (SPDT) relay.

F. Switches

1. All switches shall be digital and communicate via RS 485. Contact closure style switches shall not be acceptable. Any switch button function shall be able to be changed locally (at the DTC or a PC) or remotely, via modem, Internet or Ethernet.

2. Switches shall be available in 1 through 6-button version with engraveable buttons, red LED annunciation for each button and a constantly on green LED locator.

3. Switches may be programmed to be Momentary ON, Momentary OFF, Toggle or Maintained. These functions shall be able to be changed locally (at the DTC or a PC) or remotely, via modem.

4. Contractor to verify all switch types and quantities per plans and specifications.

5. Accessories available to include digital key switch and digital key enable switch.

G. DTC - Digital Electronic Time Clock:

1. A Digital Time Clock (DTC) shall control and program the entire lighting control system and supply all time functions and accept interface inputs.

2. DTC shall be capable of up to 32 schedules. Each schedule shall consist of one set of On and Off times per day for each day of the week and for each of two holiday lists. The schedules shall apply to any individual relay or group of relays.

3. The DTC shall be capable of controlling up to 126 digital devices on a single bus and capable of interfacing digitally with other individual busses using manufacturer supplied interface cards.

4. The DTC shall accept control locally using built in button prompts and use of a 8 line 21-letter display or from a computer or modem via an on-board RS 232 port. All commands shall be in plain English. Help pages shall display on the DTC screen.

5. The DTC shall be run from non-volatile memory so that all system programming and real time clock functions are maintained for a minimum of 15 years with loss of power.

6. Software pre-installed to accept standard Unity Graphical Management Software (GMS) pages. GMS software shall provide via local or remote PC a visual representation of each device on the bus, show real time status and the ability to change the status of any individual device, relay or zone.

7. Pre-Installed modem that allows for remote programming from any location using a PC. Modem to include all necessary software for local or remote control.

8. DTC shall provide system wide timed overrides. Any relay, group or zoned that is overridden On, before or after hours, shall automatically be swept Off by the DTC a maximum of 2 hours later.

H. Interfaces: For future expansion capability, system to have available all of the following interfaces. Verify and install only those interfaces indicated on the plans.

1. A dry contact input interface card that provides 14 programmable dry contact closure inputs. Use shielded cable to connect input devices to interface card.

2. Interface card providing digital communication from one system bus to another system bus, allowing up to 12,000 devices to communicate.

3. An exterior (PCO) or interior (PCI) photocell that provides readout on the DTC screen in number values analogous to foot-candles. Each photocell shall provide a minimum of 14 trigger points. Each trigger can be programmed to control any relay or zone. Each trigger shall be set through programming only. Photocells which requires the use of setscrews or which must be programmed at the photocell control card shall be not acceptable.

4. An interface card that allows the DTC to control up to 32 digital XCI brand thermostats. Programming of thermostats to be able to done locally (at the DTC or a PC) or remotely, via modem, Internet or Ethernet.

5. A voice prompted telephone override interface module. Interface module shall accept up to 3 phone lines and allow up to 3 simultaneous phone calls. Voice prompted menu and up to 999 unique pass codes shall be standard with each interface module.

6. Software pre-installed to run Unity GX Graphical Management Software (GMS-GX) pages. GMS-GX software shall provide via local or remote PC a visual representation of a specific area or the total area of the project. GMS full graphic pages shall be designed to the LAWA's specifications. Provide 2 GMS pages.

7. Direct digital interface to Smart Panelboards. Smart Panelboard circuits shall appear on the system software as distinct items and maintain all functions and features of

the system software to include GMS pages.

8. Direct digital interface to DMX 512 based systems. Lighting control system shall provide 14 global DMX commands, each of which can be modified locally or remotely using lighting controls manufacturer supplied software. DMX interface shall be integral to the system bus and shall connect and be controlled via a single Category 5, 4 twisted pair cable, providing real time two-way communication between lighting control system and a DMX based system.

9. BMS interface to be provided and coordinated with mechanical controls contractor as required.

## 2.2 MODES OF OPERATIONS

A. DTC – Digital Electronic Time Clock: DTC shall control any relay or group of relays by the following modes: ON only, OFF only, Maintained, Maintained with timer and OFF sweep warning (Blink warn), maintained with timer (No blink warning). Timers adjustable from 1 minute to 4 hours. When the scheduled program in the DTC is ON the associated timers are disabled. When the scheduled program in the DTC is off and a relay or zone is overridden, the DTC will put that relay or zone into the timer mode and automatically sweep off at the end of the programmed timer period (Maximum 2-Hour Timed Override). All DTC settings, schedules, photocell trip points, temperature settings, longitude and latitude, time zone offset to sunrise and sunset and any other LAWA settings shall be able to be changed though software locally (at the DTC or a PC) or remotely, via modem, Internet or Ethernet. No exceptions.

B. Switches: All system switches shall be digital and daisy chained on a single category 5, 4 twisted pair cable with all LCPs. Any switch button shall be able to control any relay or group of relays anywhere on the system in the following modes: ON, OFF, Mixed (Some relays ON some OFF), Toggle (first push ON, next OFF etc.) Maintain. Timer ON with a time set from 1 minute to 4 hours. Timer ON with Off sweep warning, (Blink warning 5 min or as programmed prior to OFF sweep). Timer ON with Horn Warning (Horn output turns ON for the warning 5 min or as programmed prior to OFF sweep). Any switch function shall be able to changed locally (at the DTC or a PC) or remotely, via modem, Internet or Ethernet. Any relay, group or zoned that is overridden On, before or after hours, shall automatically be swept Off by the DTC a maximum of 2 hours later.

# PART 3 - EXECUTION

## 3.1 EQUIPMENT INSTALLATION

A. Mount smart breaker panelboards to wall. Attach to backing or structure similar to standard panelboards. Locate strategically to allow access to low and live voltage compartments. Vacuum all construction debris prior to installing electronics.

B. Switches: Provide outlet boxes, single or multi-gang, as shown on the plans for the low voltage digital switches. Mount switches as per plans. Supply faceplates per plans and specifications. EC is specifically responsible to supply and install the required low voltage cable, Category 5, 4 twisted pair, with pre-assemble RJ45 connectors and snagless boots (commonly referred to as a Cat 5 patch cable) between all switches and panels. Field-test all Cat 5 patch cable with a recognized cable tester. All low voltage wire to be run in conduit, per local codes.

C. Wiring

1. Do not mix low voltage and high voltage conductors in the same conduit. No exceptions.

2. Ensure low voltage conduits or control wires do not run parallel to current carrying conduits.

3. Place manufacturer supplied “terminators” at each end of the system bus per manufacturer instructions.

4. Neatly lace and rack wiring in cabinets.

5. Plug in Category 5, 4-twisted pair patch cable that has been field tested with a recognized cable tester at the indicated RJ45 connector provided with each lighting control device, per manufacturer instructions.

6. Use Category 5, 4 twisted pair patch cable for all system low voltage connections. Additional conductors may be required to compensate for voltage drop with specific system designs. Contact LC&D or refer to the GR2400 manual for further information. Use shielded cable for dry contact inputs to lighting control system.

7. Do not exceed 4,000ft-wire length for the system bus.

8. All items on the bus shall be connected in sequence (daisy chained). Star and spur topologies are not acceptable.

9. The specified lighting control system shall be installed by the electrical contractor who shall make all necessary wiring connections to external devices and equipment, to include photocell. EC to wire per manufacturer instructions.

3.2 DOCUMENTATION

A. Each Smart breaker Panelboard shall have properly filled up directory. Provide a point-to-point wiring diagram for the entire lighting control system. Diagram must indicate exact mounting location of each system device. This accurate “as built” shall indicate the loads controlled by each relay and the identification number for that relay, placement of switches and location of photocell. Original to be given to LAWA, copies placed inside the door of each LCP.

## 3.3 SERVICE AND SUPPORT

A. Start Up: EC shall contact manufacturer at least 7 days before turnover of project. Manufacturer will remotely dial into the lighting control system, run diagnostics and confirm system programming. EC shall be available at the time of dial in to perform any corrections required. EC is responsible for coordinating with GC and LAWA the installation of a dedicated telephone line or a shared phone line with A/B switch. Phone jack to be mounted within 12" of Master LCP. Label jack with phone number. EC to connect phone line from jack to Master LCP.

B. Telephone factory support shall be available at no additional cost to the LAWA both during and after the warranty period. Factory to pre-program the lighting control system per plans and approved submittal, to the extent data is available. The specified manufacturer, at no added cost, shall provide additional programming via modem as required by LAWA for the operation life of the system. Manufacturer warrants that the DTC software can be upgraded and monitored remotely. Upon request manufacturer to provide remote dial up software at no added cost to LAWA. No exceptions.

C. Provide a factory technician for on-site training of the LAWA's representatives and maintenance personnel. Coordinate timing with General Contractor. Provide 2 days of factory on-site training for a minimum of ten people.

D. On Call Service

1. Control contractor shall perform monthly system diagnostics (viewing system log files and review of performance/error data logged in the system).

2. Provide one technician for 120 hours total (duration of site visit determined on time required to perform the system review) for a period of six (6) months after final acceptance of the project. Time may also be utilized by LAWA to provide as-needed modifications, troubleshooting, and/or clarifications to the system. Use of time is as the sole discretion of LAWA.

## 3.4 WARRANTY

A. Two (2) years parts and labor.

B. Five (5) years limited parts and labor warranty for repair and replace of defective system components.

END OF SECTION

# SECTION 26 12 16
# SUBSTATION: VACUUM PRIMARY BREAKER, VPI DRY TRANSFORMERS, SECONDARY SWITCHBOARD

## PART 1 - GENERAL

### 1.1 SCOPE

A. The Contractor shall furnish and install the primary and/or secondary substation transformers as specified herein and as shown on the contract drawings.

### 1.2 RELATED SECTIONS

A.

### 1.3 REFERENCES

A. The substation transformers shall be designed, manufactured and tested in accordance with the latest applicable standards of NEMA and ANSI. NEMA 201, 210; IEEE 100, ANSI C57

B. Primary Drawout Breaker refer to Specification Section 26 13 13, Item 2.6 Breaker and Item 2.7 Protective Relays.

C. Secondary Switchboard refer to spec. 26 24 13

D. DOE 2016 required efficiencies per CFR Title 10 Chapter II Part 431 Appendix A of Subpart K 2016

### 1.4 SUBMITTALS – FOR REVIEW/APPROVAL

A. The following information shall be submitted to the Engineer:

1. Master drawing index
2. Front view elevation and weight
3. Plan view
4. Schematic diagrams
5. Nameplate diagram
6. Component list

7. Conduit entry/exit locations

8. Ratings including:

   a. kVA

   b. Primary and secondary voltage

   c. Taps

   d. Primary and secondary continuous current

   e. Basic Impulse Level

   f. Impedance

   g. Insulation class and temperature rise

   h. Sound level

9. Cable terminal sizes.

10. Product data sheets.

B. Where applicable, the following additional information shall be submitted to the Engineer:

1. Busway connection

2. Connection details between close-coupled assemblies

3. Composite floor plan of close-coupled assemblies (vacuum primary breaker, secondary switchboard).

4. Key interlock scheme drawing and sequence of operations

1.5 SUBMITTALS – FOR CONSTRUCTION

A. The following information shall be submitted for record purposes:

1. Final as-built drawings and information for items listed in Section 1.04, and shall incorporate all changes made during the manufacturing process.

2. Wiring diagrams

3. Certified production test reports

4. Installation information

5. Seismic certification as specified

1.6 QUALIFICATIONS

A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly. The entire substation; primary vacuum breaker, dry type transformer and secondary switchboard shall be of a single manufacturer.

B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of twenty-five (25) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

D. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of the California Building Code (CBC) through Site Classification D. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, CBC: a peak of 2.15g's, and a ZPA of 0.86g's applied at the base of the equipment. The tests shall fully envelop this response spectrum for all equipment natural frequencies up to at least 35 Hz.

1. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.

   a. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon approved shake table tests used to verify the seismic design of the equipment.

   b. The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.

   c. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

1.7 REGULATORY REQUIREMENTS

1. UL label required Type VPI. Comply with DOE 2016 requirements per CFR Title 10 Chapter II Part 431 Appendex A of Subpart K 2016.

2. Nationally recognized testing lab label and listing for primary drawout vacuum breaker.

3. UL 891 listed and labeled secondary switchboard.

1.8 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.9 OPERATION AND MAINTENANCE MANUALS

A. Equipment operation and maintenance manuals shall be provided with each assembly shipped and shall include instruction leaflets, instruction bulletins and renewal parts lists where applicable, for the complete assembly and each major component.

1.10 FIELD MEASUREMENTS

A. Measure primary and secondary voltages and make appropriate Tap adjustments.

PART 2 - PRODUCTS – DRY-TYPE TRANSFORMERS

2.1 MANUFACTURERS

A. Eaton / Cutler-Hammer products.

B. Square D.

C. General Electric.

D. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer ten (10) days prior to bid date.

2.2 RATINGS

A. The ratings of the transformer shall be as follows or as shown on the drawings:

| | |
|---|---|
| kVA Rating | (as shown on drawings) [AA/FFA based on temp. rise]<br>115 deg. C rise unless shown as 80 deg. on drawing. |
| Impedance | 5.75% +/- 7-1/2% - ANSI standard Tolerance unless shown otherwise on the drawings |
| HV | 4160V Delta |
| HV BIL | 60kV |
| HV De-energized Taps | +/- 2 - 2-1/2% full capacity |

| | |
|---|---|
| LV | (as shown on drawings) Volts Wye |
| LV BIL | 10kV |

2.3 CONSTRUCTION

A. Future forced air (FFA) units for 300 kVA and above shall include all necessary wiring and the relay required for the automatic control of future fans (not included) to increase the kVA rating by 33%. Include the electronic temperature monitor and fan control unit. The temperature monitor and fan control relay shall include digital readout, GREEN – power on, YELLOW – fan on, RED – high temperature indicating lights; audible high temperature alarm with alarm silence pushbutton; max. temperature memory with read and reset switch; auto/manual fan control switch, system test switch; temperature sensing in all three low-voltage coils. Auxiliary alarm contact and means for remote control and temperature monitoring shall be provided. Control power shall be provided from internal control power transformer.

B. The electrical insulation system shall utilize Class H material in a fully rated 220 degrees C system. Transformer design temperature rise shall be based on a 30 degrees C average ambient over a 24-hour period with a maximum of 40 degrees C. Solid insulation in the transformer shall consist of inorganic materials such as porcelain, glass fiber, electrical grade glass polyester, electrical grade epoxy, or Nomex. All insulating materials must be rated for continuous 220 degree C duty. The insulation between the high- and low-voltage coils shall be more than sufficient for the voltage stress without the need of a varnish.

C. The transformer shall be designed for a temperature rise of 115 degrees C and shall be capable of operating at 17 % above base nameplate kVA capacity continuously without any loss of life – for those transformers that are indicated as 80 degrees C temp rise on the plan drawings, the additional kVA capacity shall be 35% above base nameplate kVA continuously.

D. The transformer shall be designed to meet the sound level standards for dry-type transformers as defined in NEMA TR1. The measurement procedure shall be as specified in ANSI C57.12.90.

E. The transformer shall be UL labeled.

F. The transformer shall be of explosion-resistant, fire-resistant, air-insulated, ventilated dry-type construction, and cooled by the natural circulation of air through the windings.

G. High-voltage and low-voltage windings shall be copper. Insulation between layers of the windings shall be by Insuldur paper or equal.

H. The high- and low-voltage coil assembly shall be Vacuum Pressure Impregnated (VPI) polyester.

I. The high- and low-voltage coil assembly shall be preheated to evaporate any moisture, then placed into a vacuum pressure tank. The air in the tank shall be evacuated; and at extremely low absolute pressure, all air bubbles are to be drawn out of the insulating materials. The resin shall be introduced to a level that submerges all parts while the vacuum is maintained for approximately one (1) hour. Then the vacuum shall be released and pressure applied for approximately 1/2 hour, after which the coil shall be removed and placed in an oven for several

hours in order for the resin to catalyze into a composite mass, completely sealing and binding the winding.

J. The transformer shall be supplied in a knockdown case design, for ease in fitting through limited openings, and shall be of heavy gauge sheet steel construction, equipped with removable panels for access to the core and coils. Front and rear panels shall incorporate lowered ventilating grills.

## 2.4 ACCESSORIES

A. Transformer shall include:

1. Diagram instruction plate

2. Provisions for lifting and jacking

3. Removable center panel for access to high-voltage strap-type connector taps for de-energized tap changing

4. Two ground pads with continuous ground bus

## 2.5 FINISH

A. The paint shall be applied using an electrostatically deposited dry powder system to a minimum of three (3) mils average thickness. Outdoor dry-type transformer units shall include suitable outdoor paint finish. Units shall be painted ANSI 61 for indoor service or outdoor service and shall match the primary and secondary equipment.

## 2.6 PRIMARY AND SECONDARY SUBSTATION REQUIREMENTS

A. The substation supplied shall include a HV drawout vacuum circuit breaker with protective relay. Refer to spec. 26 13 13 Items 2.6 and 2.7 for the requirements of the circuit breaker and associate protective relay. Control power for the breaker controls and relay shall be provide by a control power transformer connected on the line side of the primary breaker. The primary shall be close-coupled to the VPI dry transformer enclosure.

B. The substation supplied shall include a LV secondary switchboard. The switchboard enclosure shall be close-coulded to the secondary of the VPI dry transformer enclosure. Connections between the primary device and transformer shall be cable, and between the transformer and secondary shall be flexible bus braid. The secondary switchboard main breaker shall be drawout construction. The secondary switchboard shall have the main and feeder breakers individually metered using Eaton PowerXpert Multi-Point metering (PXMP) integrated into the switchboard. Refer to spec. 26 24 13 for the switchboard construction requirements, including the PXMP metering requirements.

# PART 3 - EXECUTION

## 3.1 FACTORY TESTING

A. The following standard factory tests shall be performed on all equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.

1. Resistance measurements of all windings on the rated voltage connection of each unit and at the tap extremes of one unit only of a given rating on this project

2. Ratio tests on the rated voltage connection and on all tap connections

3. Polarity and phase-relation tests on the rated voltage connections

4. No-load loss at rated voltage on the rated voltage connection

5. Exciting current at rated voltage on the rated voltage connection

6. Impedance and load loss at rated current on the rated voltage connection of each unit and on the tap extremes of one unit only of a given rating on this project

7. Applied potential test

8. Induced potential tests

9. For dry-type and cast-coil units, the manufacturer shall perform additional 100% quality control impulse test on the primary windings of each unit

B. The manufacturer shall provide three (3) certified copies of factory test reports.

C. The following special factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest revision of ANSI and NEMA standards.

1. Temperature test(s) shall be made on one unit only of a project covering one or more units of a given kVA rating. Tests shall not be required when there is an available record of a temperature test on an essentially duplicate unit. When a transformer is supplied with auxiliary cooling equipment to provide more than one rating, temperature tests as listed above shall be made on the lowest kVA OA or AA rating and the highest kVA FA rating.

## 3.2 FIELD QUALITY CONTROL

A. Provide the services of a qualified factory-trained manufacturer’s representative to assist the contractor in installation and startup of the equipment specified under this section for a period of 5 working days. The manufacturer’s representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained herein.

B. The Contractor shall provide three (3) copies of the manufacturer’s field startup report.

## 3.3 MANUFACTURER'S CERTIFICATION

A. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.

B. The Contractor shall provide three (3) copies of the manufacturer's representative's certification.

## 3.4 TRAINING

A. The contractor shall provide a training session for up to five (5) owner's representatives for 2 normal workdays at a job site location determined by the owner.

B. The training session shall be conducted by a manufacturer's qualified representative. Training program shall include instructions on the transformer, auxiliary devices and other major components.

## 3.5 INSTALLATION

A. The Contractors shall install all equipment per the manufacturer's recommendations and the contract drawings.

B. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

## 3.6 FIELD ADJUSTMENTS

A. Adjust taps to deliver appropriate secondary voltage.

## 3.7 FIELD TESTING

A. Measure primary and secondary voltages for proper tap settings.

B. Megger primary and secondary windings.

END OF SECTION

# SECTION 26 13 13
# METAL-CLAD SWITCHGEAR (VACCLAD) – MEDIUM VOLTAGE

## PART 1 - GENERAL

### 1.1 SUMMARY

A. This section applies to any 4160V installation or system.

B. The Contractor shall furnish and install the equipment as specified herein.

### 1.2 REFERENCES

A. The metal-clad switchgear and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of NEMA SG-4 and SG-5, and but not limited to, ANSI/IEEE 37.20.2. Equipment shall be UL Listed and Labeled based on the ANSI/IEEE standard of construction.

### 1.3 SUBMITTALS FOR REVIEW/APPROVAL

A. The following information shall be submitted to LAWA:

1. Master drawing index.
2. Front view elevation.
3. Floor plan.
4. Top view.
5. Single line diagram.
6. Nameplate schedule.
7. Component list.
8. Conduit entry/exit locations.
9. Assembly ratings including:
    a. Short-circuit rating.
    b. Voltage.
    c. Continuous current.

d. Basic impulse level for equipment over 600 volts.

10. Major component ratings including:

a. Voltage.

b. Continuous current.

c. Interrupting ratings.

11. Cable terminal sizes.

12. Product data sheets.

B. Where applicable, the following additional information shall be submitted to LAWA:

1. Busway connection.

2. Connection details between close-coupled assemblies.

3. Composite floor plan of close-coupled assemblies.

4. Key interlock scheme drawing and sequence of operations.

5. Descriptive bulletins.

C. Submit shop drawings after Short Circuit and Overcurrent Protective Device Coordination Study is approved. Shop drawings submitted without approved study will be returned and not reviewed.

D. The AIC ratings of all submitted equipment must conform to the approved Short Circuit and Overcurrent Protective Device Coordination Study.

E. The electrical contractor shall submit ¼”=1’0” scale sketches of all electrical rooms and areas including actual dimensions of all equipment in electrical rooms and indicate clearances per NEC, as well as door swings or other obstacles. Sketches shall be submitted along with or prior to shop drawing submittals. Shop drawing submittal without sketches shall be returned and not reviewed.

## 1.4 SUBMITTALS FOR CONSTRUCTION

A. The following information shall be submitted for record purposes:

1. Final as built drawings and information for items listed in Section 1.3 above, and shall incorporate all changes made during the manufacturing process.

2. Wiring diagrams.

3. Certified production test reports.

4. Installation information including equipment anchorage provisions.

5. Seismic certifications as specified.

1.5 QUALIFICATIONS

A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.

B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of twenty-five (25) years. When requested by LAWA, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

D. Provide Seismic tested equipment as follows:

1. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of the International Building Code (IBC) & California Building Code (CBC) Sections 1704 through 1708 for Site Classification D application and highest 1.5 importance factor. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, IBC: a peak of 2.45g's (3.2-11 Hz), and a ZPA of 0.98g's applied at the base of the equipment. The tests shall fully envelop this response spectrum for all equipment natural frequencies up to at least 35 Hz. The certificate of compliance with the requirements shall show that the shake table tested forces that the equipment can withstand exceed the Site Classification D requirements by a 15% margin. Equipment must utilize the shake table test method; computer modeling, calculations or historical data are not acceptable.

2. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.

a. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon approved shake table tests used to verify the seismic design of the equipment.

b. The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.

c. The equipment manufacturer shall document the requirements necessary for

proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

E. All switchgear shall have Los Angeles Department of Building and Safety approved lab test certification.

1.6 DELIVERY, STORAGE AND HANDLING

A. All new switchgear delivered to the jobsite, shall be stored in a covered and conditioned area where it is protected from the corrosive marine environment at the airport.

B. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

C. Shipping groups shall be designed to be shipped by truck, rail, or ship. Indoor groups shall be bolted to skids. Breakers and accessories shall be packaged and shipped separately.

D. Split shipping packages are a must to accommodate designed access hatchway.

E. Switchgear shall be equipped to be handled by crane. Where cranes are not available, switchgear shall be suitable for skidding in place on rollers using jacks to raise and lower the groups.

F. Switchgear being stored prior to installation shall be stored so as to maintain the equipment in a clean and dry condition. If stored outdoors, indoor gear shall be covered and heated, and outdoor gear shall be heated.

1.7 OPERATION AND MAINTENANCE MANUALS

A. Equipment operation and maintenance manuals shall be provided with each assembly shipped, and shall include instruction leaflets and instruction bulletins for the complete assembly and each major component. Submit spare parts listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals. It shall also include original shop drawings, and recommended maintenance, Manufacturer's Certification.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Cutler Hammer/Eaton.

B. Square D.

C. General Electric.

D. The listing of specific manufacturers above does not imply acceptance of their products which do not meet the specified ratings, features, or functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

## 2.2 RATINGS

A. The switchgear described in this specification shall be designed for medium voltage, three- phase, 3 wire, solidly grounded, 60-hertz system.

B. Each circuit breaker shall have the following ratings (values are to be verified by the engineer of record and compared to the specific voltage requirements for any improvement work at the airport):

1. Maximum Voltage: 5 kV.

2. BIL Rated: 170 kV Peak.

3. Continuous Current:

   a. 3000A for mains and tie.

   b. Feeders – 1200 A.

4. Short-Circuit Current at rated Maximum kV: 40 kA RMS SYM

5. Rated Voltage Range Factor K: 1.0

6. Closing and Latching Capability: 108 kA Crest

7. Maximum Symmetrical Interrupting and 3-Second Rating: 40 kA RMS SYM

8. Rated Interrupting Time: Cycle 3

## 2.3 CONSTRUCTION

A. The switchgear assembly shall consist of individual vertical sections housing various combinations of circuit breakers and auxiliaries, bolted to form a rigid metal-clad switchgear assembly. Metal side sheets shall provide grounded barriers between adjacent structures and solid removable metal barriers shall isolate the major primary sections of each circuit. Hinged rear doors, complete with provisions for padlocking, shall be provided.

B. The stationary primary contacts shall be silver-plated and recessed within insulating tubes. A steel shutter shall automatically cover the stationary primary disconnecting contacts when the breaker is in the disconnected position or out of the cell. The circuit breakers shall be a roll- out design to allow withdrawal for inspection and maintenance without the use of a separate lifting device.

2.4 BUS

A. The main bus shall be copper with fluidized bed epoxy flame-retardant and track-resistant insulation. The bus supports between units shall be flame-retardant, track-resistant, cycloaliphatic epoxy for medium voltage class. The switchgear shall be constructed so that all buses, bus supports and connections shall withstand stresses that would be produced by currents equal to the momentary ratings of the circuit breakers. Insulated copper main bus shall be provided and have provisions for future extension. All bus joints shall be plated, bolted and insulated with easily installed boots. The bus shall be braced to withstand fault currents equal to the close and latch rating of the breakers. The temperature rise of the bus and connections shall be in accordance with ANSI standards and documented by design tests.

B. A copper ground bus shall extend the entire length of the switchgear.

2.5 WIRING / TERMINATIONS

A. The switchgear manufacturer shall provide suitable terminal blocks for secondary wire terminations and a minimum of 10% spare terminals shall be provided. One control circuit cutout device shall be provided in each circuit breaker housing. Switchgear secondary wire shall be #14 AWG, type SIS rated 600 volt, 90 degrees C, furnished with wire markers at each termination. Wires shall terminate on terminal blocks with marker strips numbered in agreement with detailed connection diagrams.

B. Incoming line and feeder cable lugs of the type and size indicated elsewhere shall be furnished.

2.6 CIRCUIT BREAKERS

A. The circuit breakers shall be horizontal drawout type, capable of being withdrawn on rails. The breakers shall be operated by a motor-charged stored energy spring mechanism, charged normally by a universal electric motor and in an emergency by a manual handle. The primary disconnecting contacts shall be silver-plated copper.

B. Each circuit breaker shall contain three vacuum interrupters separately mounted in a self-contained, self-aligning pole unit, which can be removed easily. The vacuum interrupter pole unit shall be mounted on cycloaliphatic epoxy supports for medium voltage class. A contact wear gap indicator for each vacuum interrupter, which requires no tools to indicate available contact life, shall be easily visible when the breaker is removed from its compartment. The current transfer from the vacuum interrupter moving stem to the breaker main conductor shall be a non-sliding design. The breaker front panel shall be removable when the breaker is withdrawn for ease of inspection and maintenance.

C. The secondary contacts shall be silver-plated and shall automatically engage in the breaker operating position, which can be manually engaged in the breaker test position.

D. Interlocks shall be provided to prevent closing of a breaker between operating and test positions, to trip breakers upon insertion or removal from housing and to discharge stored energy

mechanisms upon insertion or removal from the housing. The breaker shall be secured positively in the housing between and including the operating and test positions.

E. The breakers shall be electrically operated by the following control voltages: 240V AC close and AC capacitor trip.

F. Each breaker shall be complete with control switch and red and green indicating lights to indicate breaker contact position.

G. AC control voltage shall be derived from control transformers mounted in the switchgear. A separate control transformer shall be provided on each side of the tie breaker. An automatic throwover control scheme shall be provided and factory wired to provide reliable control power to the entire lineup when one incoming source has failed, but the other source is available. Each control transformer shall be sized to handle the control load of the entire lineup.

## 2.7 PROTECTIVE RELAYS

A. The switchgear manufacturer shall furnish and install, in the metal-clad switchgear, the quantity, type and rating of protection relays and described hereafter in this specification.

B. Microprocessor-Based Protective Relay.

C. FP-5000 Protective Relay.

1. The protective relays for the Mains/Tie & Feeder circuit protection shall be a single multifunction, microprocessor-based relay that provides three-phase and ground instantaneous and time overcurrent protection, ANSI 50/51, 50/51G, or 50/51N, and voltage protection, metering and control functions as described below. The relay shall be Cutler-Hammer device type FP-5000 or approved equal having all the features and functions herein specified. The relay shall include directional relay function 67 to detect when future solar generated power is exceeding the instantaneous load of the LAWA/tenant distribution system. Solar power shall not be exported to LADWP, so tripping of the breaker is required when the directional current protective function indicated power flowing toward LADWP.

2. The relay shall be a solid-state microprocessor-based multifunctional type that operates from the 5 ampere secondary output of current transformers. The relay shall provide ANSI 50/51 protective functions for each of the three (3) phases, and ANSI 50/51N or 50/51G ground fault protection functions as shown on the plans or as determined by the coordination study. The relay shall be true rms sensing of each phase and ground. Ground element shall be capable of being utilized in residual, zero sequence, ground source connection schemes, or deactivated.

3. The relay shall provide the following protection functions:

a. Phase overcurrent (forward/ reverse (67) or both (50/51)): Two inverse time overcurrent (51P-1, 51P-2) functions and two instantaneous overcurrent (50P-1,

50P-2) functions with adjustable time delay.

b. Directional Ground inverse time overcurrent and two instantaneous overcurrent functions from calculated values with adjustable time delay (forward/reverse (67G), or both (51G, 50G-1, 50G-2)).

c. Directional Ground inverse time overcurrent and two instantaneous overcurrent functions from measured values with adjustable time delay (forward/reverse (67G), or both (51X, 50X-1, 50X-2)).

d. Ground directional option for Zero Sequence Voltage Polarizing, Negative Sequence Polarizing or Ground Current Polarizing.

e. Negative sequence overcurrent protection with adjustable time delay (46).

f. Three-phase overvoltage protection with adjustable time delay (59).

g. Three-phase undervoltage protection with adjustable time delay (27).

h. Over frequency protection with adjustable time delay (81O).

1) Negative sequence overvoltage protection with adjustable time delay (47).

i. Under frequency protection with adjustable time delay (81U).

j. Breaker failure protection with adjustable time delay (50BF).

k. Reverse/Forward Power (32-1, 32-2).

l. Sync Check (25). m. Power Factor (55).

1) The primary current transformer ratings being used for phase and ground protection feeding the device shall be programmable for current transformers with primary current ratings from 1 through 6,000 amperes, in 1 ampere steps.

2) The ground current input and ground protection elements shall be independent of the phase inputs and shall be capable of being connected to the phase residual current transformer connection or to a zero sequence current transformer.

3) Both the phase and ground protection curves shall be independently field selectable and programmable with or without load. Curves shall be selectable from the following:

a) ANSI/IEEE: Moderately inverse, very inverse, and extremely

inverse. II). IEC: A, B or C.

b) Thermal: Flat, It, I2t, I4t.

c) Thermal curves shall be similar to those on low voltage trip units for close coordination with downstream devices.

4) The relay shall have six trip rated contact outputs that may be programmed for any protection function operation output.

5) The relay shall have a front panel display of relay condition, breaker status and trip condition.

6) The relay shall have a built-in alphanumeric display capable of displaying the following information with metering accuracy phase current +/- 0.5% or +/-0.025A from 0.02 to 20.0 per unit, ground current +/- 0.5% of full scale (In) from 0.2 to 2.0 per unit.

n. Individual phase and ground currents with phase angles.

o. Phase-to-ground and phase-to-phase voltages with phase angles.

p. Watts.

q. VARs.

r. VA.

s. Frequency.

t. Power factor – apparent and displacement.

u. Demand and Peak demand (ampere, Watt, VAR, and VA) with date and time stamp since last reset.

1) Forward, reverse and net watthours with start date and time stamp.

v. Lead, lag and net VAR hours with start date and time stamp.

w. VA-hours with start date and time stamp.

x. Minimum/maximum values of current, voltage, watts, VARs, VA, frequency, apparent pf and displacement pf with date and time stamping.

y. Percent THD of voltage and current.

z. Positive, negative and zero sequence components of voltage and current with

phase angles.

4. Relay shall have the following features:

   a. Integral manual testing capability for both phase and ground overcurrent protection functions.

   b. Zone selective interlocking capability for phase and ground fault protection. This function shall be provided and factory wired. Where zone selective interlocking is not an integral part of the protective device, a full bus differential scheme shall be required for both phase and ground, in addition to specified time overcurrent and instantaneous overcurrent phase and ground fault protection. Bus differential scheme shall be provided with separate differential current transformers for all incoming and outgoing loads, as well as appropriate differential relays (ANSI 87 and 87G) as approved by LAWA.

   c. Real-time clock for stamping of events, trips and minimum/maximum values with 1 mS time resolution.

   d. Trip coil-monitoring circuits.

   e. User interface for programming and retrieving data from the front of the unit without additional equipment.

   f. Eight (8) contact inputs that are user programmable.

   g. Continuous self-testing of internal circuitry.

   h. Self-diagnostic capability and a relay healthy alarm output.

   i. Integral test program for testing the relay operation by simulating current and voltage conditions internally.

   j. Unit failure alarm contact for customer use.

   k. Programmable lockout/self-reset after trip function.

   l. Programmable set points for device curve selection.

   m. Programmable inputs, such as current transformer ratios.

   n. Access to program and test modes shall be via sealable hinged cover and password protected for security.

5. Relay shall record information on the last 16 faults including:

   a. Date, time, currents and voltages at the time of fault.

b. Waveforms of the voltages and currents.

6. Relay shall record the last 100 events into an event log with date and time stamping.

7. Relay shall have programmable logic control functions including logic gates and timer for control of auxiliary functions

8. Relay shall provide and retain relay communication address and check sum setting verification in non-volatile memory chip within the permanently installed case.

9. Relay shall be suitable for operating temperatures from -30 degrees to 55 degrees C. Relay shall be suitable for operating with humidity from 0 to 95% relative humidity (non-condensing).

10. Relay shall have the following communications ports:

    a. A rear communication port that is FSK based and supports local area network compatible to Cutler-Hammer PowerNet or IMPACC systems.

    b. A rear communication port that is RS-485 based and supports the Modbus RTU protocol.

    c. A front communication port supporting ASCI communications to a personal computer or laptop computer.

    d. Relay shall be capable of the following over the communication network: Ability to transmit all information contained in the relay such as currents, set points, cause of trip, magnitude of trip current, waveforms and open-close trip status. Ability to close and open the associated breaker with proper access code from remote location over the communication network when the relay is configured in remote close/open mode.

11. Relay shall have communication ability to open and close the breaker remotely via password protected access or locally from the front of the relay.

12. Relay shall store four setting groups which can be called for via communications, front panel operation or contact input.

13. Relay trip contacts shall not change state if power is lost or an undervoltage occurs. These contacts shall only cause a trip upon detection of an overcurrent or fault condition based upon programmed settings.

14. A relay healthy alarm output shall be normally energized and shall drop out if a relay failure is detected in the self-test function or if control power is lost.

15. The relay shall be suitable for operating on control power with a nominal input voltage of 125 Vac or 250 Vac (60 Hz). When AC control power schemes required, in addition

to control power transformer or remote control power are specified, a single-phase uninterruptable power supply shall be included to supply control power to protective devices.

2.8 AUXILLIARY DEVICES

A. Ring type current transformers shall be furnished. The thermal and mechanical ratings of the current transformers shall be coordinated with the circuit breakers. Their accuracy rating shall be equal to or higher than ANSI standard requirements. Shorting terminal blocks shall be furnished on the secondary of all the current transformers.

B. Voltage and control power transformers of the quantity and ratings indicated in the detailed specification shall be supplied. Voltage transformers shall be mounted in drawout drawers contained in an enclosed auxiliary compartment. Control power transformers up to 15 kV, 15 kVA, single-phase shall be mounted in drawout drawers. Rails shall be provided as applicable for each drawer to permit easy inspection, testing and fuse replacement. Shutters shall isolate primary bus stabs when drawers are withdrawn.

C. A mechanical interlock shall be provided to require the secondary breaker to be open before the CPT drawer or CPT primary fuse drawer can be withdrawn.

D. Automatic load shedding system and sequence shall be provided for the 4160V and 1st level 480V at the double ended switchgear. Full redundancy at LAWA 4160V switchgear and 1st level 480V switchgear is required. Substation, switchgear estimated demand loads not to exceed 50% of substation/switchgear ratings.

2.9 AUTOMATIC THROWOVER SYSTEM OPEN TRANSITION

A. Dual Source, With Tie, Open Transition Automatic Transfer Control System.

1. Provide an automatic transfer control system for control of three circuit breakers. The logic of the transfer control system functions shall be provided via a microprocessor. The set points shall be field adjustable without the use of special tools

2. The transfer control system shall be provided with a local display. The display shall show the status of the system as it is operating. When timers are functioning, the display shall show the timer counting down. All time delays shall be capable of being set from the front of the display using a timer setting screen.

3. The transfer control system includes the following features:

a. Time delay to transfer on loss of Source 1, adjustable.

b. Time delay to transfer on loss of Source 2, adjustable.

c. Time delay re-transfer to Source 1, adjustable.

d. Time delay re-transfer to Source 2, adjustable.

e. Time delay neutral (main and tie open), adjustable.

f. The local system display shall show the following: Main- Tie- Main one line diagram; main and tie breaker status (open, closed, tripped, out of cell); readout marked "Source 1" and "Source 2" to indicate that respective source voltages are available; automatic/manual mode select pushbutton; pushbuttons for manual breaker control; and alarm information (loss of source, breaker trip).

4. Sequence of Operation – Automatic Mode

a. Under normal conditions, the main breakers are closed and the tie breaker is open.

b. Upon phase loss or loss of phase-to-phase voltage of either utility source to between 80% and 100% of nominal, and after a time delay, adjustable from 1 to 60 seconds to override momentary dips and outages the transfer control system shall open the affected main breaker and close the tie breaker.

c. When normal voltage has been restored after a time delay, adjustable from 10 to 600 seconds (to ensure the integrity of the source), the transfer control system shall open the tie breaker. The transfer control system shall have an adjustable neutral position timer (0-10 seconds) to allow voltage to decay sufficiently before the affected main breaker is then closed (open transition re-transfer).

d. If Source 2 should fail while carrying the load, transfer to Source 1 shall be made instantaneously upon restoration of Source 1 to satisfactory conditions.

e. If both sources should fail simultaneously, no action shall be taken.

f. If the main or tie breakers trip due to a fault, the transfer control system shall be reset to manual mode and manual operation of that breaker shall be prevented until its overcurrent trip switch is reset.

5. Sequence of Operation – Manual Mode

a. While in manual mode, breakers shall be capable of being opened and closed using control switches or pushbuttons on the transfer control system display. Electrical interlocking shall be provided to prevent the closing of both mains and the tie simultaneously.

6. Provide a control power transformer for each source with control power transfer scheme.

7. Provide electrically operated main and tie circuit breakers.

8. Provide a programmable logic controller with 24 volts dc ride-through power supply.

9. Provide an industrial display panel.

2.10 LAWA METERING

A. Provide a separate LAWA metering devices and compartment with front hinged doors. Include associated instrument transformers.

B. Provide current transformers for metering. Current transformers shall be wired to shorting type terminal blocks.

C. Provide potential transformers including primary and secondary fuses with disconnecting means for metering.

D. Microprocessor-based metering system. Power Xpert 8000

1. Provide a microprocessor based line of Power Quality complete 8000 Meters, designated PX-M consisting of a Power Quality Meter Base(s) designated PX-B along with an integrally mounted Power Quality Meter Display designated PX-D. The PX-M shall be equal to Cutler-Hammer type Power Xpert 8000 as herein specified. PX-B shall be NEMA 1 rated and PX-D shall be NEMA 12 rated.

2. Complete PX-8000 shall be have the following minimum listings and/or certifications:

a. Safety: UL 61010A-1, EN 610101.

b. Accuracy: ANSI C12.20 Class 0.2, IEC/EN60687 0.2 for revenue meters.

c. EMC: FCC Part 15 Subpart B Class A immunity.

d. IEC Standards: 50081-2, 61000-3, 61000-4, and 61000-6.

3. Meter shall be supplied suitable for standard 120/240 VAC as required.

4. Current inputs for each channel shall be from standard instrument current transformers.

a. The analog current input shall be converted to 1024 samples per cycle with a delta-sigma converter digitally filtered down to 256 samples per cycle for anti-aliasing.

b. Meter burden shall be less than 10 milliohms.

c. Overload withstand capability shall be a minimum of 500A for 1 second, non- repeating.

d. Input range capability shall be 0.005 to 20 amperes.

5. Voltage inputs for each channel shall allow for connection into circuits with the following parameters:

a. Input range of 600V L-L, 347V L-N direct connected.

b. PT primary input of 120 volts to 500,000 volts.

c. Nominal full-scale value of 700 volts rms.

d. Input impedance of 2 mega ohms.

e. The analog voltage input shall be converted to 1024 samples per cycle by means of a delta sigma converter and digitally filtered down to 256 samples per cycle for anti- phasing.

6. The PX-Metering series shall be capable of monitoring, displaying, and communicating the below true rms minimum information where applicable with the accuracy as indicated of read or calculated values based on 3 to 300% full scale. The PX-Metering series shall be suitable for installation in single phase, two or three wire systems or in three phase, three or four wire systems.

a. AC current (amperes) in A, B and C phase, 3-phase average, Neutral (N) and Ground (G). A total of five (5) current inputs shall be provided. Accuracy of all current inputs shall be 0.05% reading, +/- 0.01% of full scale. Provide neutral and ground current transformers. The 5 ampere current inputs shall withstand 40 amperes continuous and 300 amperes for 1 second. Current transformer ratios shall be selectable.

b. AC voltage (volts) for A-B, B-C and C-A, phase average, A-N, B-N and C-N, average phase to N, and N to G. Accuracy of all voltage inputs shall be +/- 0.1% reading, +/-0.05% maximum of full scale. Capable of metering up to 600 volt without external Potential Transformers (PTs) and up to 500 kV with appropriate PTs.

c. Real Power (Watts), Reactive Power (VARs), Apparent Power (VA), for each phase and system. Accuracy +/- 0.10% reading and +/- 0.0025% full scale. Forward/Reverse indication shall be provided.

d. Accumulated, Incremental and conditional measurement for Real Energy (WH), Reactive Energy (VARH), Apparent Energy (VAH) for each phase and system. Accuracy +/- 0.10% reading and +/- 0.0025% full scale. Forward/Reverse and Net difference indication shall be provided.

e. Frequency (Hz) Accuracy +/- 0.01 hertz.

f. Demand values including present, running average, last complete interval and peak for System Current (Amperes). Demand values including present, running average, last complete interval, peak and coincident with peak kVA and kW demand for System Real Power (Watts), System Reactive Power (VARs), and System Apparent Power (VA).

g. Power Factor for both Displacement only 60-cycle fundamental Watts to VA and Apparent total Watts to total VARs including harmonics for A, B and C phase and 3 phase average. Accuracy +/- 0.10% at unity PF and +/-0.30% at 0.5 PF.

h. Current percent Total Harmonic Distortion (THD) in A, B and C phase and N.

1) Voltage percent THD in A-B, B-C and C-A phase, A-N, B-N and C-N.

i. K-Factor (sum of the squares of harmonic currents times the square of their harmonic numbers).

j. Transformer Derating Factor (1.414 divided by the Crest Factor).

k. Crest Factor (ratio of peak current to rms current).

l. CBEMA (ITIC) curve data.

m. Flicker data.

n. Nines (9's) availability data.

o. Power Quality Index.

7. The PX series shall provide the following sampling capabilities:

a. A/D technology, sampling at 1024 samples per cycle.

b. Over-sampling and quantizing filtering to eliminate false signal noise.

c. ITIC representation of power events.

d. DV/dt triggers for sub-cycle oscillatory transients. Both dv/dt and absolute threshold triggering shall be supported on all voltage inputs, including N-G voltage.

e. Six (6) MHz/ one (1) MHz capture of impulsive transients. 20 ms of data shall be captured at six (6) MHz or 120 ms of data shall be captured at one (1) MHz.

f. Waveform recorded at 100,000 high rate samples per cycle. Waveforms shall be displayed on standard web browser without requiring separately purchased and installed software.

g. Three-phase voltage and neutral-to-ground fast transient capture.

h. Absolute threshold and dV/dt triggering.

8. The PX series shall provide the following advanced analysis features:

a. Calculation of harmonic magnitudes and phase angle for each phase voltage and current through the 85th harmonic.

b. Waveforms shall be available in non-volatile memory and retrievable via file transfer protocol (FTP) in COMTRADE file format over the Internet network. No special software shall be required to download or view waveforms. Waveforms shall be viewable within standard web browser.

c. Historical Trending: Historical trend logging for graphical viewing from the Local PX-D display or from an embedded WEB server. The graphical views of historical data shall support both pan and zoom functions. All standard metering parameters shall be logged as part of the standard meter functionality including minimum, maximum and average for each metered parameter. The minimum and maximum readings shall be based on 200ms calculations. The averages shall be calculated over the user selected time interval period. Minimum storage capacity for standard trend plots shall be as follows:

1) One-minute intervals for 9 days.

2) Sixty-minute intervals for 540 days.

3) Data storage up to 512 MB.

d. Time of Use Monitoring: Time of use monitoring shall include:

1) Four rate periods for time of use revenue metering.

2) Total rate independent of time of use.

3) Up to 4 rate schedules (weekdays and weekends).

e. Energy Profile: Energy profile data shall include recording of real and reactive energy forward, reverse, net and absolute sum as well as apparent energy (KVAH). Up to eight (8) status inputs shall be configurable as energy accumulators for counting KYZ pulse inputs. These readings shall be stored over a configurable interval from 1 to 60 minutes as well as in daily and weekly totals. Storage capacity shall be as follows:

1) Sixty-two (62) days of fifteen (15) minute interval energy and pulse interval data (Fixed interval capacity shall equal 5,952 intervals configurable from 1 to 60 minutes).

2) Three hundred and seventy-two (372) days of 1 day accumulated energy and pulse interval data.

3) Two Hundred and eight (208) weeks of one (1) week accumulated energy and pulse interval data.

f. Event Triggers: The PX-M shall have a quantity of five (5) types of configurable event triggers configurable using a web browser consisting of 1) Out of limits, 2) Demand overload, 3) ITIC, 4) Sub-Cycle disturbance and 5) Fast Transient. The web browser shall not require any user-installed software. These triggers shall permit pickup, reset and pickup delay to be user configurable. When a trigger occurs, actions shall include Performance monitoring (Nines (9s) analysis, capturing Waveform, Capture all metered parameters, and ability to send by email and/or activate a relay output. The meter graphic display PX-MD shall flash an LED to annunciate the alarm condition and an audible alarm shall be available. The following trigger options shall be included:

1) Out of limits – one hundred and five (105) triggers.

2) Demand overload – Ten (10) triggers.

3) ITIC curve display sag or swell voltage events – Eight (8) triggers.

4) Fast transient – dV/dt and absolute per phase.

5) Sub-cycle disturbance – dV/dt and absolute.

g. Event Logging: The PX-M or embedded WEB Server shall allow the user to view a list of triggered events along with any captured parameters, event details, and triggered waveforms. In addition, a separate event log shall include logging of activities including acknowledged triggers, new minimum and maximum events, and systems operations, such as resets. The size of each event log shall be virtually unlimited based only on the memory option selected.

h. ITIC Analysis Plot: The PX-M or embedded WEB Server shall include a graphic display of the Information Technology Industry Council (ITIC) plot with counts of disturbances and transients that have occurred. The ITIC plot shall organize events into eight (8) distinct disturbance zones corresponding to the severity of the event and a ninth (9th) zone for transients. A pass/fail count shall be displayed to indicate how many events are outside the ITIC limits. Operator clicking of any counter, or the event itself in the ITIC WEB page shall link the user to the event view and display all triggered events in the selected zone making it easy to view disturbance waveforms associated with the ITIC plot.

i. Sag/Swell and Waveform recording: Sixty (60) cycles of waveform shall be recorded at 256 samples per cycle including 30 cycles of pre and post event data.

The embedded WEB server shall be capable of supporting viewing of all triggered waveforms one channel at a time and shall include the ability to zoom and to scroll horizontally using a slider bar. Waveforms shall be stored in non-volatile flash memory using industry standard COMTRADE format. Waveforms shall be automatically sent out as COMTRADE attachments to an email following an event, or shall be retrievable from an FTP directory structure from the meter's memory.

j. Minimum and Maximum values for the following parameters:

1) Voltage L-L and L-N.

2) Current per phase.

3) Apparent Power Factor and Displacement Power Factor.

4) Real, Reactive, and Apparent total Power.

5) THD voltage L-L and L-N.

6) THD Current per phase.

7) Frequency.

9. The PX-8000 meter base and display shall have a digital Input/Output (I/O) card which shall include:

a. Eight (8) digital inputs – self sourced 24 Vdc. These shall be interrupt driven, allowing for 1ms accuracy of digital events time stamps when utilizing local NTP server. Inputs shall be configurable for demand synch, and pulse counting. Inputs selected for pulse counting shall be scalable. Interval by interval pulse recordings shall be maintained in the PX-M/PX-B profile memory and shall be capable of being displayed graphically.

b. Three (3) relay outputs – 5A maximum form C continuous, 380Vac maximum, 125Vdc maximum. Outputs shall be suitable for KYX or alarm annunciation. Relay outputs shall have the following minimum ratings:

1) Make: 30A, 30 VDC, 120-240 VAC.

2) Break: 5A, 30 VDC, 120-240 VAC.

3) Resistive load: 0.5A, 125VDC; 0.25A, 250 VDC.

4) Mechanical Operations: 1,000,000 no-load and 100,000 under rated voltage and current.

5) Output Relay when event triggered shall be capable of operating in timed, normal or latched mode.

c. Two (2) solid state outputs – 80 mA maximum continuous, 30 Vdc maximum.

10. The PX-8000 base and display shall be provided with multiple communications ports and protocols, including the following minimum capability:

a. RS-232

b. RS-485

c. RJ-45 10/100 Base-T Local Ethernet Configuration Port for local WEB server connection

d. Modbus RTU

e. Modbus TCP

f. HTML web pages

g. File transfer protocol (FTP)

h. Ethernet TCP/IP

11. The PX-8000 graphically display shall utilize a simple "twist and click" navigation control dial to easily navigate the menus, select links to related pages, and to drill down into increasing levels of further details. A "back" key shall be provided for easy navigation to higher level screens. The graphical display shall have the following features:

a. Backlight LCD remote graphics display with 320 x 240 pixels. This display must supporting reviewing, displaying and scrolling through waveform captures without requiring a separate computer or separately purchased software.

b. Capable of being mounted to the Meter base unit or remote mounting of display up to 2000 ft away with capability of displaying up to 16 base units or complete Meters.

c. A set of screens including real time data, trend lots, waveform views and ITIC plot.

d. Allow basic device setup and password protected resets.

e. An audible alarm to annunciate alarm conditions.

12. The WEB server shall provide the user with remote WEB access to all the metered, trend

and waveform information. The WEB server shall include real time monitored information in both numeric and graphical visual formats.

13. The meter shall be cable of providing the graphically display of the following Main Meter Menu Screens:

    a. Meter Screen providing:

        1) Volts: L-L and L-N, and average.

        2) Frequency.

        3) Current and average phase A, B, and C, N & G.

    b. Power Screen providing:

        1) Energy.

        2) Demand.

        3) Power Factor.

    c. Quality Screen providing:

        1) Total Harmonic Distortion (THD) of volts and current.

        2) Flicker.

        3) Percent Nines (9s) reliability.

    d. Events screen providing:

        1) Latest events.

        2) Enabled Triggers.

        3) Historical Events.

    e. Set-up screen providing:

        1) View set-up.

        2) Edit set-up.

        3) Login.

        4) Logout.

14. A tool bar for screen selection which is always present and viewable shall be provided along the bottom of the graphical display. Selection of one of the main screens shall be by turning the navigation knob and highlighting the desired screen. Once selected, pressing the knob shall make the selection.

2.11 ENCLOSURES

A. This switchgear shall be installed indoor in NEMA 1 Enclosure. Outdoor installations will have to be justified, NEMA 4 or NEMA 3R Stainless steel gasketed and approved by LAWA.

2.12 NAMEPLATES

A. Refer to Identification for Electrical Systems for information pertaining to nameplates on equipment.

B. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.

2.13 FINISH

A. The finish shall consist of a coat of gray (ANSI-61), thermosetting, polyester powder paint applied electrostatically to pre-cleaned and phosphatized steel and aluminum for internal and external parts. The coating shall have corrosion resistance of 600 hours to 5% salt spray.

2.14 ACCESSORIES

A. The switchgear manufacturer shall furnish accessories for test, inspection, maintenance and operation, including:

1. One – Maintenance tool for manually charging the breaker closing spring and manually opening the shutter.

2. One – Levering crank for moving the breaker between test and connected positions.

3. One – Test jumper for electrically operating the breaker while out of its compartment.

4. One – Breaker lifting yoke used for attachment to breaker for lifting breaker on or off compartment rails, when applicable.

5. One – Set of rail extensions and rail clamps, when applicable.

6. One – Test cabinet for testing electrically operated breakers outside housing.

7. One – Electrical levering device.

2.15 CORONA FREE DESIGN

A. The switchgear shall be corona free by design and shall be tested for partial discharges in accordance with EEMAC standard G11-1. The corona discharges measured during the tests shall be less than 100 picocoulombs.

2.16 PARTIAL DISCHARGE SENSING EQUIPMENT

A. The switchgear shall be equipped with factory installed partial discharge sensors and relay for continuous monitoring of the partial discharges under normal operation. The purpose of partial discharge sensing is to identify potential insulation problems (insulation degradation) by trending of PD data over time so that corrective actions can be planned and implemented before permanent insulation deterioration develops.

B. The PD sensing and monitoring system shall consist of sensors and relay specifically developed for such applications, such as Eaton's RFCT sensor and InsulGard relay, or equivalent. One RFCT sensor shall be installed over floating stress shields of specially designed bus or line side primary bushings, at every two vertical section for detection of partial discharges within the switchgear compartments. An RFCT sensor shall also be provided for installation around ground shields of the incoming or outgoing power cable termination for detection of PD activity in the cables up to 100 feet from the switchgear. Output signals from each RFCT shall be factory wired to PD monitoring relay for continuous monitoring.

2.17 CONTROLS AND CONTROL TRANSFORMERS

A. The metal-clad switchgear auxiliary section for control and instrumentation shall include the following:

1. Line-to-line voltage transformers.

2. Current transformers.

3. Single-phase control power transformers with automatic throwover system. The size of the transformers shall be determined by the VacClad lineup manufacturer and each transformer shall handle the full control power load of the lineup (tie breaker closed, single source available).

4. Microprocessor-based PowerXpert 8000 metering system.

5. Automatic load shedding system and sequence shall be provided for the 4160V and 1st level 480V at the double ended switchgear. Full redundancy at LAWA 4160V switchgear and 1st level 480V switchgear is required. To accomplish, consider having new substation, switchgear estimated demand loads not exceed 50% of substation/switchgear ratings.

2.18 SOURCE QUALITY CONTROL

A. Furnish shop inspection and testing in accordance with NEMA PB 2.

B. Make completed switchboard available for inspection at manufacturer's factory prior to packaging for shipment. Notify LAWA at least seven days before inspection is allowed.

C. Allow witnessing of factory inspections and tests at manufacturer's test facility. Notify LAWA at least seven days before inspections and tests are scheduled.

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. The following standard factory tests shall be performed on the circuit breaker element provided under this section. All tests shall be in accordance with the latest version of ANSI standards.

1. Alignment test with master cell to verify all interfaces and interchangeability.

2. Circuit breakers operated over the range of minimum to maximum control voltage.

3. Factory setting of contact gap.

4. One-minute dielectric test per ANSI standards.

5. Final inspections and quality checks.

B. The following production test shall be performed on each breaker housing:

1. Alignment test with master breaker to verify interfaces

2. One-minute dielectric test per ANSI standards on primary and secondary circuits.

3. Operation of wiring, relays and other devices verified by an operational sequence test.

4. Final inspection and quality check

C. The manufacturer shall provide three (3) certified copies of factory test reports.

D. Factory tests as outlined above under 3.02.B shall be witnessed by LAWA.

1. The manufacturer shall notify LAWA two (2) weeks prior to the date the tests are to be performed.

2. The manufacturer shall include the cost of transportation and lodging for up to three (3) LAWA's representatives. The cost of meals and incidental expenses shall be LAWA's responsibility.

3.2 FIELD QUALITY CONTROL

A. Provide the services of a qualified factory-trained manufacturer's representative to assist the

Contractor in installation and startup of the equipment specified under this section for a period of 5 working days. The manufacturer's representative shall provide technical direction and assistance to the contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.

B. The Contractor shall provide three (3) copies of the manufacturer's field startup report.

3.3 MANUFACTURER'S CERTIFICATION

A. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.

B. The Contractor shall provide three (3) copies of the manufacturer's representative's certification.

3.4 TRAINING

A. The Contractor shall provide a training session for up to ten (10) LAWA's representatives for 3 normal workdays at a job site location determined by LAWA.

B. The training session shall be conducted by a manufacturer's qualified representative. Training program shall include instructions on the assembly, circuit breaker, protective devices, and other major components.

3.5 INSTALLATION

A. The Contractor shall install all equipment per the manufacturer's recommendations and contract drawings.

B. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

3.6 FIELD ADJUSTMENTS

A. The relays shall be set in the field by a qualified representative of the manufacturer, retained by the Contractor, in accordance with settings designated in a coordinated study of the system as required elsewhere in the contract documents.

END OF SECTION

# SECTION 26 22 00
# LOW-VOLTAGE TRANSFORMERS

## PART 1 - GENERAL

### 1.1 SCOPE

A. Section includes two-winding transformers.

B. Related Sections: Division 26 Series.

### 1.2 REFERENCES

A. National Electrical Manufacturers Association:

1. NEMA ST 1 - Specialty Transformers (Except General Purpose Type).

2. NEMA ST 20 - Dry Type Transformers for General Applications.

B. International Electrical Testing Association:

1. NETA ATS - Acceptance Testing Specifications for Electrical Power

2. Distribution Equipment and Systems.

C. Underwriters Laboratory:

1. UL 1561 – Dry Type General Purpose and Power Transformers

2. UL Energy Verification Label indicating compliance with CFR Title 10 Chapter II Part 431 Appendix A of subpart K (DOE 2016)

### 1.3 SUBMITTALS

A. Product Data: Submit outline and support point dimensions of enclosures and accessories, unit weight, voltage, kVA, and impedance ratings and characteristics, tap configurations, insulation system type, and rated temperature rise.

B. Test Reports: Indicate loss data, efficiency at 25, 50, 75 and 100 percent rated load, and sound level. Indicate loss data and efficiency at 35 percent rated load as required by DOE 2016.

C. The electrical contractor shall submit ¼”=1’0” scale sketches of all electrical rooms and areas including actual dimensions of all equipment in electrical rooms and indicate clearances per NEC, as well as door swings or other obstacles. Sketches shall be submitted along with or prior to shop drawing submittals. Shop drawing submittal without sketches shall be returned and not reviewed.

## 1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of transformers.

## 1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

B. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of twenty-five (25) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement. The manufacturer must be the same as the manufacturer of the switchboard on the project.

C. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of the California Building Code (CBC) through Site Classification D. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, CBC: a peak of 2.15g's, and a ZPA of 0.86g's applied at the base of the equipment. The tests shall fully envelop this response spectrum for all equipment natural frequencies
up to at least 35 Hz.

D. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.

E. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon approved shake table tests used to verify the seismic design of the equipment.

F. The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.

G. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

## 1.6 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided. Handle carefully to avoid damage to transformer internal components, enclosure, and finish.

PART 2 - PRODUCTS

2.1 TWO-WINDING TRANSFORMERS

A. Manufacturers:

1. Cutler Hammer/Eaton

2. General Electric.

3. Square D.

B. Product Description: NEMA ST 20, factory-assembled, air-cooled, dry type transformers.

C. Primary Voltage: 480 volts, 3 phase or unless otherwise noted.

D. Secondary Voltage: 208Y/120 volts, 3 phase or unless otherwise noted.

E. Insulation system and average winding temperature rise for rated kVA as follows:

1. 1-15 kVA: Class 185 with 115 degrees C rise.

2. 16-1000 kVA: Class 220 with 115 degrees C rise.

F. Case temperature: Do not exceed 35 degrees C rise above ambient at warmest point at full load.

G. Winding Taps:

1. Transformers Less than 15 kVA: Two 5 percent below rated voltage, full capacity taps on primary winding.

2. Transformers 15 kVA and Larger: NEMA ST 20.

H. Sound Levels: NEMA ST 20. Maximum sound levels are as follows:

1. 0-9 kVA: 40 dB.

2. 10-50 kVA: 45 dB.

3. 51-150 kVA: 50 dB.

4. 150-300 kVA: 55 dB.

5. 301-500 kVA: 60 dB.

6. 501-700 kVA: 62 dB.

7. 701-1000 kVA: 64 dB.

I. Basic Impulse Level: 10 kV for transformers less than 300 kVA, 30 kV for transformers 300 kVA and larger.

J. Ground core and coil assembly to enclosure by means of visible flexible copper grounding strap.

K. Mounting:

1. 1-15 kVA: Suitable for wall mounting.

2. 16-75 kVA: Suitable for wall, floor, or trapeze mounting.

3. Larger than 75 kVA: Suitable for floor mounting.

L. Coil Conductors: Continuous copper windings with terminations brazed or welded.

M. Enclosure: NEMA ST 20, Type 1 indoor, dry locations and Type 4 with weathershields for wet locationsProvide weather-resistant ANSI 61 color enamel. Where called for on the plan drawings, provide outdoor Type 4 with stainless steel exterior construction. Furnish lifting eyes or brackets.

N. Isolate core and coil from enclosure using vibration-absorbing mounts.

O. Nameplate: Include transformer connection data and overload capacity based on rated allowable temperature rise.

P. Factory Testing: The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.

1. Ratio tests at the rated voltage connection and at all tap connections

2. Polarity and phase relation tests on the rated voltage connection

3. Applied potential tests

4. Induced potential test

5. No-load and excitation current at rated voltage on the rated voltage connection.

## 2.2 SOURCE QUALITY CONTROL

A. Production test each unit according to NEMA ST20.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Verify mounting supports are properly sized and located including concealed bracing in walls.

## 3.2 INSTALLATION

A. Set transformer plumb and level.

B. Use flexible conduit, 2 feet minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.

C. Support transformers.

1. Mount wall-mounted transformers using integral flanges or accessory brackets furnished by manufacturer.

2. Mount floor-mounted transformers on vibration isolating pads suitable for isolating transformer noise from building structure.

3. Mount trapeze-mounted transformers.

D. Provide seismic restraints.

E. Comply with grounding and bonding requirement.

## 3.3 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Perform inspections and tests listed in NETA ATS, Section 7.2.1.

## 3.4 ADJUSTING

A. Measure primary and secondary voltages and make appropriate tap adjustments.

END OF SECTION

# SECTION 26 23 00
# METAL-ENCLOSED DRAWOUT SWITCHGEAR - LOW VOLTAGE

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes a deadfront type, low voltage metal-enclosed switchgear assembly utilizing drawout power circuit breakers for the Main Switchboard in each terminal.

### 1.2 REFERENCES

A. The low voltage metal-enclosed switchgear assembly and all components shall be designed, manufactured and tested in accordance with the following latest applicable standards:

1. ANSI-C37.20 - Switchgear assemblies
2. ANSI-C37.13 - Low voltage power circuit breakers
3. ANSI-C37.17 - Trip devices
4. NEMA SG-5 - Switchgear assemblies
5. NEMA SG-3 - Low voltage power circuit breakers
6. UL 1558
7. UL 819

### 1.3 SUBMITTALS – FOR REVIEW/APPROVAL

A. The following information shall be submitted to LAWA:

1. Master drawing index
2. Front view and plan view of the assembly
3. Three-line diagram
4. Schematic diagram
5. Nameplate schedule
6. Component list

7. Conduit space locations within the assembly

8. Assembly ratings including:

   a. Short-circuit rating

   b. Voltage

   c. Continuous current rating

9. Major component ratings including:

   a. Voltage

   b. Continuous current rating

   c. Interrupting ratings

10. Cable terminal sizes

11. Product data sheets

B. Where applicable, the following additional information shall be submitted to LAWA:

   1. Busway connection

   2. Composite front view and plan view of close-coupled assemblies

   3. Key interlock scheme drawing and sequence of operations

   4. Mimic bus size and color

C. Submit shop drawings after Short Circuit and Overcurrent Protective Device Coordination Study is approved. Shop drawings submitted without approved study will be returned and not reviewed.

D. AIC ratings of all submitted equipment must conform to the approved Short Circuit and Overcurrent Protective Device Coordination Study, minimum 100,000AIC.

1.4 SUBMITTALS - FOR CONSTRUCTION

A. The following information shall be submitted for record purposes:

   1. Final as-built drawings and information for items listed in Paragraph 1.04, and shall incorporate all changes made during the manufacturing process

   2. Wiring diagrams

   3. Certified production test reports

4. Installation information

5. Seismic certification as specified

1.5 QUALIFICATIONS

A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.

B. For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified. C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of ten 10 years. When requested by LAWA, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of twenty-five (25) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

D. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of the California Building Code (CBC) through Site Classification D. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, CBC: a peak of 2.15g's, and a ZPA of 0.86g's applied at the base of the equipment. The tests shall fully envelop this response spectrum for all equipment natural frequencies up to at least 35 Hz.

E. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.

F. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon approved shake table tests used to verify the seismic design of the equipment.

G. The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.

F. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

1.6 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.7 OPERATION AND MAINTENANCE MANUALS

A. Equipment operation and maintenance manuals shall be provided with each assembly shipped, and shall include instruction leaflets and instruction bulletins for the complete assembly and each major component. Submit spare parts listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals. It shall also include original shop drawings, and recommended maintenance, Manufacturer's Certification.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Cutler-Hammer/Eaton.

B. Square D.

C. General Electric.

D. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

2.2 RATINGS

A. The entire assembly shall be suitable for 600 volts maximum ac service.

B. The assembly shall be rated to withstand mechanical forces exerted during short-circuit conditions when connected directly to a power source having available fault current of 100,000 amperes symmetrical at rated voltage.

C. The bus system shall have a minimum ANSI short-circuit withstand rating of 100,000 amperes symmetrical tested in accordance with ANSI C37.20.1 and UL1558.

D. All circuit breakers shall have a minimum symmetrical interrupting capacity of 100,000 amperes. To ensure a fully selective system, all circuit breakers shall have 30 cycle short-time withstand ratings equal to their symmetrical interrupting ratings through 85,000 amperes, regardless of whether equipped with instantaneous trip protection or not.

E. All ratings shall be tested to the requirements of ANSI C37.20.1, C37.50 and C37.51 and UL witnessed and approved.

2.3 CONSTRUCTION

A. The switchgear shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide ventilators located on the top of the switchgear

over the breaker and bus compartments to ensure adequate ventilation within the enclosure. Hinged rear doors, complete with provisions for padlocking, shall be provided.

B. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to the floor without the use of floor sills providing the floor is level to 1/8 inch per 3-foot distance in any direction. Provisions shall be made for jacking of shipping groups, for removal of skids or insertion of equipment rollers. Base of assembly shall be suitable for rolling directly on pipes without skids. The base shall be equipped with slots in the base frame members to accommodate the use of pry bars for moving the equipment to its final position.

C. Each vertical steel unit forming part of the switchgear line-up shall be a self-contained housing having one or more individual breaker or instrument compartments, a centralized bus compartment and a rear cable compartment. Each individual circuit breaker compartment, or cell, shall be segregated from adjacent compartments and sections by means of steel barriers to the maximum extent possible. It shall be equipped with drawout rails and primary and secondary disconnecting contacts. Removable hinge pins shall be provided on the breaker compartment door hinges. Current transformers for feeder instrumentation, where shown on the plans, shall be located within the appropriate breaker cells and be front accessible and removable.

D. The stationary part of the primary disconnecting devices for each power circuit breaker shall be breaker mounted and consist of a set of contacts extending to the rear through a glass polyester insulating support barrier; corresponding moving finger contacts, suitably spaced, shall be furnished on the power circuit breaker studs which engage in only the connected position. The assembly shall provide multiple silver-to-silver full floating high pressure point contacts with uniform pressure on each finger maintained by springs. Each circuit shall include the necessary three-phase bus connections between the section bus and the breaker line side studs. Load studs shall be equipped with insulated copper load extension buses terminating in solderless type terminals in the rear cable compartment of each structure. Bus extensions shall be silver-plated where outgoing terminals are attached.

E. The circuit breaker door design shall be such that the following functions may be performed without the need to open the circuit breaker door: lever circuit breaker between positions, operate manual charging system, close and open circuit breaker, examine and adjust trip unit, and read circuit breaker rating nameplate.

F. The secondary disconnecting devices shall consist of floating terminals mounted on the stationary unit and engaging mating contacts at the front of the breaker. The secondary disconnecting devices shall be gold-plated and engagement shall be maintained in the “connected” and “test” positions.

G. The removable power circuit breaker element shall be equipped with disconnecting contacts and interlocks for drawout application. It shall have four positions, “connected”, “test”, “disconnected” and “removed”. The breaker drawout element shall contain a worm gear levering “in” and “out” mechanism with removable lever crank. Levering shall be accomplished via the use of conventional tools. Mechanical interlocking shall be provided so that the breaker is in the tripped position before levering “in” or “out” of the cell. The breaker shall include an optional provision for key locking open to prevent manual or electric closing. Padlocking shall provide for securing

the breaker in the connected, test, or disconnected position by preventing levering.

H. An insulating flash shield shall be mounted above each circuit breaker to prevent flashover from the arc chutes to ground.

1. The switchgear shall be suitable for use as service entrance equipment and be labeled in accordance with UL requirements.

I. Provide a rear compartment barrier between the cable compartment and the main bus to protect against inadvertent contact with main or vertical bus bars.

J. Provide in the cell when the circuit breaker is withdrawn, a safety shutter which automatically covers the line and load stabs and protects against incidental contact.

1. Provide a metal barrier full height and depth between adjacent vertical structures in the cable compartment.

K. Provide a glass polyester full height and depth barrier between adjacent vertical structures in the bus compartment with appropriate slots for main bus.

## 2.4 BUS

A. All bus bars shall be silver-plated copper. Main horizontal bus bars shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on ANSI standard temperature rise criteria of 65 degrees C over a 40 degrees C ambient (outside the enclosure).

B. Provide a full capacity neutral bus.

C. A copper ground bus shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchgear. The ground bus short-time withstand rating shall meet that of the largest circuit breaker within the assembly.

D. All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with Belleville-type washers.

E. Provide bus extensions on ends for future sections.

## 2.5 WIRING/TERMINATIONS

A. Small wiring, necessary fuse blocks and terminal blocks within the switchgear shall be furnished as required. Control components mounted within the assembly shall be suitably marked for identification corresponding to the appropriate designations on manufacturer’s wiring diagrams.

B. Provide a front accessible, isolated vertical wireway for routing of factory and field wiring. Factory provisions shall be made for securing field wiring without the need for adhesive wire anchors.

C. Front access to all circuit breaker secondary connection points shall be provided for ease of troubleshooting and connection to external field connections without the need of removing the circuit breaker for access.

D. All control wire shall be type SIS. Control wiring shall be 16 ga for control circuits and 14 ga for shunt trip and current transformer circuits. Wire bundles shall be secured with nylon ties anchors. All current transformer secondary leads shall first be connected to conveniently accessible shorting terminal blocks before connecting to any other device. Shorting screws with provisions for storage shall be provided. All groups of control wires leaving the switchgear shall be provided with terminal blocks with suitable numbering strips and provisions for #10 AWG field connections. Each control wire shall be marked to the origin zone/wire name/destination zone over the entire length of the wire using a UV cured ink process. Plug-in terminal blocks shall be provided for all shipping split wires. Terminal connections to remote devices or sources shall be front accessible via doors above each circuit breaker. Terminal blocks shall be of the latched pull-apart type.

E. NEMA 2-hole mechanical- type lugs shall be provided for all line and load terminations suitable for copper or aluminum cable rated for 75 degrees C of the size.

F. Lugs shall be provided in the incoming line section for connection of the main grounding conductor. Additional lugs for connection of other grounding conductors shall be provided.

G. Provide 25% spare terminals.

## 2.6 CIRCUIT BREAKERS

A. All protective devices shall be low voltage power circuit breakers. All breakers shall be UL listed for application in their intended enclosures for 100% of their continuous ampere rating.

B. All power circuit breakers shall be constructed and tested in accordance with ANSI C37.13, C37.16, C37.17, C37.50, UL 1066 and NEMA SG-3 standard. The breaker shall carry a UL label.

C. Breakers shall be provided in drawout configuration. The 800, 1600, 2000 and 3200 ampere frame power circuit breakers shall be provided in the same physical frame size, while 4000, 5000 and 6000 ampere frame power circuit breakers shall be provided in a second physical frame size. Both physical frame sizes shall have a common height and depth.

D. Power circuit breakers shall utilize a two-step stored-energy mechanism to charge the closing springs. The closing of the breaker contacts shall automatically charge the opening springs to ensure quick-break operation.

E. Breakers shall be electrically operated (EO).

F. Electrically operated breakers shall be complete with 120 Vac motor operators. The charging time of the motor shall not exceed 6 seconds. Control power for all switchgear control circuits shall be provided by a factory-sized control power transformer wired on the line side of the main breaker(s).

G. To facilitate lifting, the power circuit breaker shall have integral handles on the side of the breaker.

H. The power circuit breaker shall have a closing time of not more than 3 cycles.

1. The primary contacts shall have an easily accessible wear indicator to indicate contact erosion.

I. The power circuit breaker shall have three (3) windows in the front cover to clearly indicate any electrical accessories that are mounted in the breaker. The accessory shall have a label that will indicate its function and voltage. The accessories shall be plug and lock type and UL listed for easy field installation. They shall be modular in design and shall be common to all frame sizes and ratings.

J. The breaker control interface shall have color-coded visual indicators to indicate contact open or closed positions, as well as mechanism charged and discharged positions. Manual control pushbuttons on the breaker face shall be provided for opening and closing the breaker. The power circuit breaker shall have a "Positive On" feature. The breaker flag will read "Closed" if the contacts are welded and the breaker is tripped or opened.

1. The current sensors shall have a back cover window that will permit viewing the sensor rating on the back of the breaker. A rating plug will offer indication of the rating on the front of the trip unit.

K. A position indicator shall be located on the faceplate of the breaker. This indicator shall provide color indication of the breaker position in the cell. These positions shall be Connect (Red), Test (Yellow), and Disconnect (Green). The levering door shall be interlocked so that when the breaker is in the closed position, the breaker levering-in door shall not open.

L. Each power circuit breaker shall offer sixty (60) front-mounted dedicated secondary wiring points. Each wiring point shall have finger safe contacts, which will accommodate #10 AWG maximum field connections with ring tongue or spade terminals or bare wire.

## 2.7 TRIP UNITS

A. Each low voltage power circuit breaker shall be equipped with a solid-state tripping system consisting of three current sensors, microprocessor-based trip device and flux-transfer shunt trip. Current sensors shall provide operation and signal function. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection functions. True rms sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time delay settings are reached. Interchangeable current sensors with their associated rating plug shall establish the continuous trip rating of each circuit breaker.

B. The trip unit shall have an information system that utilizes battery backup LEDs to indicate mode of trip following an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip. A reset button shall be provided to turn off the LED indication after an automatic trip. A test pushbutton shall energize a LED to indicate the battery status.

C. The trip unit shall be provided with a display panel, including a representation of the time/current curve that will indicate the protection functions. The unit shall be continuously self-checking and provide a visual indication that the internal circuitry is being monitored and is fully operational.

D. The trip unit shall be provided with a making-current release circuit. The circuit shall be armed for approximately two cycles after breaker closing and shall operate for all peak fault levels above 25 times the ampere value of the rating plug.

E. Trip unit shall have selectable powered and unpowered thermal memory for enhanced circuit protection.

F. Complete system selective coordination shall be provided by the addition of the following individually adjustable time/current curve shaping solid-state elements:

1. All circuit breakers shall have adjustments for long delay pickup and time.

2. All circuit breakers shall have individual adjustments for short delay pickup and time, and include $I^2t$ settings.

3. All circuit breakers shall have an adjustable instantaneous pickup.

4. All circuit breakers shall have individually adjustable ground fault current pickup and time, and include $I^2t$ settings.

G. The trip unit shall have provisions for a single test kit to test each of the trip functions.

H. The trip unit shall provide zone interlocking for the short-time delay and ground fault delay trip functions for improved system coordination. The zone interlocking system shall restrain the tripping of an upstream breaker and allow the breaker closest to the fault to trip with no intentional time delay. In the event that the downstream breaker does not trip, the upstream breaker shall trip after the present time delay. Factory shall wire for zone interlocking for the power circuit breakers within the switchgear.

I. The trip unit shall include a power/relay module which shall supply control to the readout display. Following an automatic trip operation of the circuit breaker, the trip unit shall maintain the cause of trip history and the mode of trip LED indication as long as its internal power supply is available.

J. The trip unit shall include a voltage transformer module, suitable for operation up to 600V, 50/60 Hz. The primary of the voltage transformer module shall be connected internally to the line side of the circuit breaker through a dielectric test disconnect plug.

K. Provide a trip unit with Arc Reduction Module built into the trip unit, which includes multiple instantaneous trip set points, a normal/maintenance mode switch and indicating light to remind maintenance personnel when the switch is in the maintenance mode B all integral to the breaker trip unit. The ARMS reduction feature shall also have provisions for remote setting of the breaker into a maintenance mode.

L. For emergency Circuit breakers, provide individually adjustable ground fault alarm only.

M. The trip unit shall be equipped to permit communication via a network twisted pair for remote monitoring and control.

N. The trip unit shall include a power/relay module which shall supply control to the readout display. Following an automatic trip operation of the circuit breaker, the trip unit shall maintain the cause of trip history and the mode of trip LED indication as long as its internal power supply is available. An internal relay shall be programmable to provide contacts for remote ground alarm indication.

O. The trip unit shall include a voltage transformer module, suitable for operation up to 600V, 50/60 Hz. The primary of the voltage transformer module shall be connected internally to the line side of the circuit breaker through a dielectric test disconnect plug.

P. The display for the trip units shall be a 24-character LED display.

Q. Metering display accuracy of the complete system, including current sensors, auxiliary CTs, and the trip unit, shall be +/- 1% of full scale for current values. Metering display accuracy of the complete system shall be +/- 2% of full scale for power and energy values.

R. The unit shall be capable of monitoring the following data:

1. Instantaneous value of phase, neutral and ground current

2. Instantaneous value of line-to-line voltage

3. Minimum and maximum current values

4. Watts, VARs, VA, watthours, VARhours and VA hours

S. The energy-monitoring parameter values (peak demand, present demand, and energy consumption) shall be indicated in the trip unit’s alphanumeric display panel.

T. The trip unit shall display the following power quality values: crest factor, power factor, percent total harmonic distortion, and harmonic values of all phases through the 31st harmonic.

U. An adjustable high load alarm shall be provided, adjustable from 50 to 100% of the long delay pickup setting.

V. The trip unit shall contain an integral test pushbutton. A keypad shall be provided to enable the user to select the values of test currents within a range of available settings. The protection functions shall not be affected during test operations. The breaker may be tested in the TRIP or NO TRIP test mode.

W. Programming may be done via a keypad at the faceplate of the unit or via the communication network.

X. System coordination shall be provided by the following microprocessor-based programmable time

current curve shaping adjustments. The short-time pickup adjustment shall be dependent on the long delay setting.

1. Programmable long-time setting

2. Programmable long-time delay with selectable $I^2t$ or $I^4t$ curve shaping

3. Programmable short-time setting

4. Programmable short-time delay with selectable flat or $I^2t$ curve shaping, and zone selective interlocking

5. Programmable instantaneous setting

6. Programmable ground fault setting trip or ground fault setting alarm

7. Programmable ground fault delay with selectable flat or $I^2t$ curve shaping and zone selective interlocking.

Y. The trip unit shall offer a three-event trip log that will store the trip data, and shall time and date stamp the event.

Z. The trip unit shall have the following advanced features integral to the trip unit:

1. Adjustable undervoltage release

2. Adjustable overvoltage release

3. Reverse load and fault current

4. Reverse sequence voltage alarm

5. Underfrequency

6. Overfrequency

7. Voltage phase unbalance and phase loss during current detection

## 2.8 MISCELLANEOUS DEVICES

A. Key interlocks shall be provided. These interlocks shall keep the circuit breakers trip-free when actuated.

B. Fused control power transformers shall be provided as required for proper operation of the equipment. A manual disconnect shall be provided ahead of the primary fuses. Control power transformers shall have adequate capacity to supply power to all the control circuits within the

lineup.

2.9 LAWA METERING

A. Provide a separate LAWA metering compartment with front hinged door, where required.

B. Provide current transformers for each meter. Current transformers shall be wired to shorting-type terminal blocks.

C. Provide potential transformers including primary and secondary fuses with disconnecting means for metering.

D. Microprocessor-Based Digital Metering Unit (DMU) shall include branch circuit metering utilizing Eaton IQ-260 meters and main circuit metering utilizing IQ-2270 meters. All meters shall utilize RS-485 daisy-chained factory-supplied connection and a PowerXpert 900 Gateway per lineup for customer/contractor supplied network cable between lineups.

2.10 ENCLOSURES

A. This switchgear shall be installed indoor in NEMA 1 Enclosure. Outdoor installations will have to be justified, NEMA 4 or NEMA 3R Stainless steel gasketed and approved by LAWA. Except for Stainless Steel applications, the paint finish shall be ANSI 61 color powder-coat paint process-applied enamel, tested for 600 hours salt spray.

2.11 NAMEPLATES

A. Engraved nameplates, mounted on the face of the assembly, shall be furnished for all main and feeder circuits. Refer to Electrical Identification for additional information.

B. Furnish master nameplate giving switchgear designation, voltage ampere rating, short-circuit rating, and manufacturer’s name.

C. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer’s drawings.

D. Refer to Identification for Electrical Systems for information pertaining to nameplates on equipment.

2.12 FINISH

A. All exterior and interior steel surfaces of the switchgear shall be properly cleaned and provided with a rust-inhibiting phosphatized coating. Color and finish of the switchgear shall be ANSI 61.

2.13 ACCESSORIES

A. Provide a floor running portable circuit breaker transfer truck with manual lifting mechanism, one for each concourse main electrical room.

## PART 3 - EXECUTION

### 3.1 FACTORY TESTING

A. The switchgear shall be completely assembled, wired, adjusted and tested at the factory. After assembly, the complete switchgear shall be tested to ensure the accuracy of the wiring and the functioning of all equipment. The main bus system shall be given a dielectric test of 2200 volts for one minute between live parts and ground and between opposite polarities.

B. The wiring and control circuits shall be given a dielectric test of 1500 volts for one minute, or 1800 volts for one second, between live parts and ground, in accordance with ANSI C37.20.1.

C. A certified test report of all standard production tests shall be shipped with each assembly.

D. Factory test as outlined above shall be witnessed by LAWA's representative.

1. The manufacturer shall notify LAWA two (2) weeks prior to the date the tests are to be performed

2. The manufacturer shall include the cost of transportation and lodging for up to three (3) LAWA's representatives. The cost of meals and incidental expenses shall be LAWA's responsibility

### 3.2 FIELD QUALITY CONTROL

A. Provide the services of a qualified factory-trained manufacturer's representative to assist the Contractor in installation and start-up of the equipment specified under this section for a period of 5 working days. The manufacturer's representative shall provide technical direction and assistance to the contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.

B. The Contractor shall provide three (3) copies of the manufacturer's field startup report.

### 3.3 MANUFACTURER'S CERTIFICATION

A. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.

B. The Contractor shall provide three (3) copies of the manufacturer's representative's certification before final payment.

## 3.4 TRAINING

A. The Contractor shall provide a training session for up to ten (10) LAWA's representatives for 2 normal workdays at a job site location determined by LAWA.

B. The training session shall be conducted by a manufacturer's qualified representative. The training program shall consist of the instruction on the operation of the assembly, circuit breakers, and major components within the assembly.

## 3.5 INSTALLATION

A. The Contractors shall install all equipment per the manufacturer's recommendations.

B. The Contractor shall ensure that the switchgear installation shall provide at a minimum physical floor space for one additional switchgear section at each line-up end. A double ended switchgear will require two section floor spaces, one at each end. The Contractor shall properly mark these spaces for future expansion.

C. All necessary hardware to secure the assembly in place shall be provided by the Contractor.

D. The equipment shall be installed and checked in accordance with the manufacturer's recommendations. This shall include but not limited to:

1. Checking to ensure that the pad location is level to within 0.125 inches per three foot of distance in any direction

2. Checking to ensure that all bus bars are torqued to the manufacturer's recommendations

E. Assembling all shipping sections, removing all shipping braces and connecting all shipping split mechanical and electrical connections.

F. Securing assemblies to foundation or floor channels.

G. Measuring and recording Megger readings phase-to-phase, phase-to-ground, and neutral-to-ground (four wire systems only).

H. Inspecting and installing all circuit breakers in their proper compartments.

END OF SECTION

# SECTION 26 24 13
# SWITCHBOARDS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes main and distribution switchboards.

B. Related Sections: Division 26 Series.

### 1.2 REFERENCES

A. American National Standards Institute:

1. ANSI C12.1 - Code for Electricity Metering.

2. ANSI C39.1 - Requirements, Electrical Analog Indicating Instruments.

B. Institute of Electrical and Electronics Engineers:

1. IEEE C57.13 - Standard Requirements for Instrument Transformers.

2. IEEE C62.41 - Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.

C. National Electrical Manufacturers Association:

1. NEMA FU 1 - Low Voltage Cartridge Fuses.

2. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

3. NEMA PB 2 - Deadfront Distribution Switchboards.

4. NEMA PB 2.1 - General Instructions for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less.

D. International Electrical Testing Association:

1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

2. UL891 and UL1066.

E. Underwriters Laboratories Inc.:

1. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.

## 1.3 SUBMITTALS

A. Shop Drawings: Indicate front and side views of enclosures with overall dimensions shown; conduit entrance locations and requirements; nameplate legends; size and number of bus bars for each phase, neutral, and ground; and switchboard instrument details.

B. Product Data: Submit electrical characteristics including voltage, frame size and trip ratings, fault current withstand ratings, and time-current curves of equipment and components.

C. The electrical contractor shall submit ¼”=1’0” scale drawings including interior elevations of all electrical rooms and areas including actual dimensions of all equipment in electrical rooms and indicate clearances per NEC, as well as door swings or other obstacles. These drawings shall be submitted along with or prior to shop drawing submittals. Shop drawing submittal without sketches will be returned and not reviewed.

D. The equipment depicted on the plans and interior elevations shall match the equipment indicated on the shop drawings.

E. Test Reports: Indicate results of factory production and field tests.

## 1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations, configurations, and ratings of switchboards and their components on single line diagrams and plan layouts.

B. Operation and Maintenance Data: Submit spare parts data listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

## 1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum five years documented experience.

B. The manufacturer of the switchboard assembly shall be the same as the manufacturer of the circuit breakers installed within the assembly.

C. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of the California Building Code (CBC) through Site Classification D. Guidelines for the installation consistent with these requirements shall be provided by the

switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, CBC: a peak of 2.15g's, and a ZPA of 0.86g's applied at the base of the equipment. The tests shall fully envelop this response spectrum for all equipment natural frequencies up to at least 35 Hz.

D. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.

E. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed civil engineer in the state. Mounting recommendations shall be provided by the manufacturer based upon approved shake table tests used to verify the seismic design of the equipment.

F. The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.

G. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Accept switchboards on site. Inspect for damage.

B. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, water, construction debris, and traffic.

C. Handle in accordance with NEMA PB 2.1. Lift only with lugs provided. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

1.7 ENVIRONMENTAL REQUIREMENTS

A. Conform to NEMA PB 2 service conditions during and after installation of switchboards.

1.8 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

PART 2 - PRODUCTS

2.1 DISTRIBUTION SWITCHBOARDS

A. Manufacturers:

1. Cutler-Hammer/Eaton.

2. GE Electrical.

3. Square D.

B. Product Description: NEMA PB 2, enclosed switchboard.

C. Switchboards shall be "fully-rated" for the available short circuit current. "Series-rated" equipment is not acceptable. Main 480 volt service switchboards in the terminals shall be rated 100kAIC.

D. Device Mounting: (Panel Mounted devices)

1. Main Section: Panel mounted.

2. Distribution Section: Panel mounted.

E. 1. Device Mounting: (Draw-out Type Mounted devices):

1. Main Section: Draw-out type.

2. Distribution Section: Draw-out type.

F. Bus:

1. Material: Copper with silver or tin plating standard size.

2. Connections: Bolted, accessible from front for maintenance.

3. Provide bus extensions on ends for future sections.

G. Ground Bus: Extend length of switchboard.

H. Line and Load Terminations: Accessible from front only of switchboard, suitable for conductor materials and sizes as shown on contract document.

I. Future Provisions: Fully equip spaces for future devices with bussing and bus connections, insulated and braced for short circuit currents. Leave space in design for one spare section to be added. Provide footprint area for future expansion.

J. Switchboard Height: 90 inches, excluding floor sills, lifting members and pull boxes.

K. Finish: Manufacturer's standard light gray enamel over external surfaces. Coat internal surfaces

with minimum one coat corrosion-resisting paint or plate with cadmium or zinc.

L. Short Circuit Rating: The short circuit rating of the equipment shall exceed 130% of the available short circuit current at the equipment.

M Furnish a set of two keys for each Nema 4 switchboard.

2.2 MOLDED CASE CIRCUIT BREAKER

A. Molded Case Circuit Breakers are for typical frame sizes ranging from 110A to 2500A.

B. Manufacturers:

1. Cutler-Hammer/Eaton.

2. General Electric.

3. Square D.

C. Product Description: UL 489, molded-case circuit breaker.

D. Field-Adjustable Trip Circuit Breaker: Circuit breakers with frame sizes 200 amperes and larger have mechanism for adjusting long time short time continuous current; short time long time pickup current setting for automatic operation.

E. Field-Changeable Ampere Rating Circuit Breaker: Circuit breakers with frame sizes 200 amperes and larger have changeable trip units.

F. Solid-State Circuit Breaker: Electronic sensing, timing, and tripping circuits for adjustable current settings; ground fault trip with integral ground fault sensing instantaneous trip; and adjustable short time trip. For circuit breakers that can be adjusted to 1200A, provide a trip unit with Arc Reduction Module built into the trip unit, which includes multiple instantaneous trip set points, a normal/maintenance mode switch and indicating light to remind maintenance personnel when the switch is in the maintenance mode B all integral to the breaker trip unit. The ARMS reduction feature shall also have provisions for remote setting of the breaker into a maintenance mode.

G. Accessories:

1. Shunt Trip Device.

2. Undervoltage Trip Device.

3. Auxiliary Switch.

4. Alarm Switch.

5. Electrical Operator.

6. Handle Lock: Provisions for padlocking.

7. Grounding Lug: In each enclosure.

H. Circuit Breakers: 225A and above shall be electronic trip type.

I. Circuit breakers with trip ratings 400 amps and larger shall be 100% rated, and have electronic trips manufactured by Eaton.

2.3 INSULATED CASE CIRCUIT BREAKER

A. Molded Case Circuit Breakers are for typical frame sizes ranging from 800A to 6000A.

B. Manufacturers:

1. Cutler-Hammer/Eaton.

2. General Electric.

3. Square D.

C. Product Description: UL 489, enclosed, insulated-case circuit breaker.

D. Trip Unit: Electronic sensing, timing, and tripping circuits for adjustable current settings; ground fault trip with integral ground fault sensing instantaneous trip; and adjustable short time trip. Provide a trip unit with Arc Reduction Module built into the trip unit, which includes multiple instantaneous trip set points, a normal/maintenance mode switch and indicating light to remind maintenance personnel when the switch is in the maintenance mode B all integral to the breaker trip unit. The ARMS reduction feature shall also have provisions for remote setting of the breaker into a maintenance mode.

E. Incorporating any of the below accessories is dependent on the design of the new electrical system.

F. Accessories:

1. Shunt Trip Device.

2. Undervoltage Trip Device.

3. Auxiliary Switch.

4. Alarm Switch.

5. Electrical Operator.

6. Handle Lock: Provisions for padlocking.

7. Grounding Lug: In each enclosure.

2.4 POWER METERS

A. Power meters are to meter the entire switchboard. Tenant sub metering may be required.

B. Provide electronic power meter to indicate the following parameters.

1. Voltage: Phase-Phase and Phase-Neutral.

2. Current in Each Phase.

3. KW.

4. KVA.

5. KVAR.

6. Power Factor.

7. Current Demand.

8. Maximum Demand.

9. Kwhour.

C. For Tenant sub metering, provide the following system:

1. Meters shall be Eaton PowerXpert Multi-Point metering system (PXMP) and shall comply with UL 1244.

2. Meters used for billing shall have an accuracy of 0.5 percent of reading, complying with requirements in ANSI C12.20.

3. Meters shall be certified by California Type Evaluation Program as complying with Title 4, California Code of Regulations, Article 2.2.

4. Enclosure: NEMA 250, Type 1 minimum, with hasp for padlocking or sealing.

5. Metering systems for submetering and electricity measurement/cost allocation shall be certified by the California Department of Weights and Measures. The metering system Certification shall be listed on the State website.

6. Identification: Comply with requirements in Division 26 Section "Identification for Electrical Systems."

7. Memory Backup: Self-contained to maintain memory throughout power outages of 72 hours, minimum.

8. Sensors: Current-sensing type, with current or voltage output, selected for optimum range and accuracy for meters indicated for this application.

   a. Type: Split and solid core.

9. Current-Transformer Cabinet: Listed or recommended by metering equipment manufacturer for use with sensors indicated.

10. Building Automation System (BAS) Interface: One digital KY pulse to a user-definable increment of energy measurement. Match signal to BAS input and arrange to convey the instantaneous, integrated, demand level measured by meter to provide data for processing and possible programmed demand control action by destination system.

11. Provide communication port with protocol to match the building LAN and provide the interface to the remote third party billing service for periodic reading of registers and data necessary to generate billing documents and cost allocation reports.

12. Third Party Billing Service: Automatically export energy-usage records to a third party billing service to compute and prepare tenant bills activity demand and energy-use statements based on metering of energy use and peak demand. Maintain separate directory for each tenant's historical billing information. Prepare summary reports in user-defined formats and time intervals.

13. Where electricity metering and/or cost allocation is shown on the draw-ings, supply a UL listed microprocessor-based Multi-Point Metering Sys-tem (MPM), Eaton type PX Multipoint Meter or approved equal having the specified features. This system shall consist of current sensors, meter base, and meter module(s) as described below

14. The MPM shall have the capability to monitor 60 single-phase two-wire ac loads, 30 single-phase three-wire ac loads or 20 three-phase four-wire ac loads or any combination thereof by use of current sensors

15. All connections to the MPM shall be through removable plugs

16. The device shall be capable of accepting input from current sensors by connecting with factory installed plug connectors

17. The device shall automatically sense the rating of the current sensor

18. The device shall provide a mechanism for detecting tampering with the current sensors.

Tamper detection shall be accessible remotely by com-puter

19. The MPM shall be available to accept service type rating from 120-600 Vac voltage rating

20. The device shall calculate power and energy consumption in accordance with ANSI C12.20 (0.5%) metering specification and stored in non volatile memory

21. The device shall store the following per phase and system total for each metering point

    a. Voltage, Current, and Frequency (system total only)

    b. Real Power in Watts, Reactive power in Var, Apparent energy in VA, and power factor

    c. Real Energy in Watt hours including forward and reverse, Reactive energy in Var hours in Q1-Q4, Apparent energy in VA hours in Q1/Q4, Q2/Q3

22. The MPM shall store energy profile information for each metering point in non volatile memory. The demand profile time period shall be adjustable from 1, 5, 15, 30 and 60 minutes for fixed method and 1, 5, and 15 minutes for sliding method. The MPM shall have the ability to sync with external input to the on board demand input. The MPM shall be able to save a minimum of 1 year of load profile data for all 60 meter points on a 15 minutes basis

23. The device shall be suitable for mounting within a panelboard or switch-board. The device may also be mounted in a separate enclosure

24. The MPM shall have the capability to scale the number of metering points from 6 to 60 in increments of 6

25. The MPM shall be UL and cUL listed

26. The MPM shall have LEDs that can be easily viewed when the unit is in-stalled to aid in the installation and operation of the device with the fol-lowing functionality:

    a. Each meter base shall have: an LED to indicate power is applied to the unit; an LED to indicate the proper functioning of the system; an LED to indicate the proper functioning of the system; three LEDs, one per phase, to indicate the voltage is within the range of the set nominal voltage; LEDs to indicate Delta and Wye operation; and LEDs to indicate transmit and receive status on RS 485 link.

    b. Each meter module shall have: two programmable LEDs that shall flash in proportion to the amount of energy flowing in the measures circuit with each LED can be assigned to one, two, or three phases; six LEDs that indicate the

direction of energy flow per phase; an LED to indicate the proper functioning of the mod-ule; and an LED to indicate the proper functioning of communica-tion between the meter base and the meter module.

c. Each pulse input module shall have: eight LEDs, one per input, to indicate the pulse input status; an LED to indicate the proper functioning of the module; an LED to indicate the proper functioning of communication between the meter base and the input module; and eight LEDs, one per output, to indicate the pulse output status.

d. Each pulse output module shall have: an LED to indicate the proper functioning of the module; and an LED to indicate the proper functioning of communication between the meter base and the output module.

27. The MPM shall have rotary address switches that are easily accessible that set the unit address on the communication network

28. The MPM shall have two Modbus RTU ports. The communication speed at the device level shall be a minimum of 9,600 baud and maximum 57,600 baud. Devices shall communicate at their maximum baud rate re-gardless of the number of devices on the network

29. Meter modules shall be available with support for two three-pole circuits, three two-pole circuits, or six single-pole circuits.

30. Meter modules shall be available to accept 10 mA, 100 mA or 333 mV input signals.

31. Current sensors shall be provided with a toroidal winding over solid core. The winding shall be mounted over the circuit to be monitored by insert-ing the load conductor through a hole in the center of the current trans-formers. The current in the load conductor shall be made available to an electronic monitoring device through a four-conductor cable and terminated to a removable plug on the current sensor. The current sensor shall have two LEDs, one red for indicating loss of connection and one blue for verification to connected load. The current sensors shall be suitable for use with circuits rated 125 A through 400 A. Extension cables, with a length of 8 and 16 feet and factory installed connectors shall be available for installations where the standard cable is too short for proper installation. The current sensors shall have 600 V rated cable insulation and shall be UL listed with the MPM

32. The MPM shall be provided with multiple communications ports and protocols, including the following capability:

a. RS-485 remote display port

b. RS-485 Modbus RTU

c. USB Local Configuration Port

d. HTML web pages

e. File transfer protocol (ftp)

f. RJ-45 10/100Base-T Ethernet network port

g. Modbus TCP, Ethernet TCP/IP or BACnet/IP as required to match facility LAN

33. The WEB server shall provide the user with remote WEB access to all the metered and trend information with the optional Energy Portal Module. The WEB server shall include real time monitored information in both numeric and graphical visual formats.

a. Administrators shall have the following capabilities: add, remove and configure the user accounts; view all the energy, demand, power, voltage, current and power factor measurements available in the meter; and ability to map the meters to the accounts and us-ers.

b. User accounts shall have the following capabilities: view the energy and demand measurements specific to their account; and display the event logs, system logs and load profile data.

34. The meter shall have a real-time clock with the added capability to syn-chronize with a network time server to maintain time accuracy.

35. The MPM shall have a configuration utility installed on a disc or down-loadable from the manufacturer's website to install on a PC.

a. The configuration utility shall be able to provide online and offline configuration.

b. The configuration utility shall have a wizard to guide the user in step by step setup.

c. The configuration utility shall be able to load a previously saved configuration, save a configuration, and print a configuration.

d. The configuration utility shall be able to configure the service type, set PT and CT ratios, set demand type and intervals along with reset capability on a specific day, configure inputs and outputs, set time, add admin and users with different authorization levels, assign meters to tenants, set alarms and limits, and set network parameters for optional energy portal module.

36. The meter display shall be capable of providing the following Main Meter Menu Screens:

a. System Meter Screen providing:

1) Current per phase and average phase for A, B, and C

2) Volts: L-L and L-N

3) Power, Power Factor and Frequency

4) Power per phase

5) Demand

6) Peak Demand and Timestamp

7) Energy

b. Sub Meter Screen providing:

1) Configuration

2) Power, Power Factor and Frequency

3) Demand

4) Peak Demand and Timestamp

5) Energy

c. Events Screen providing:

1) Latest 20 events with date and timestamps

d. System Information Screen providing:

1) Name

2) Part Number

3) Serial Number and Date Code

e. Module Information Screen providing:

1) Name

2) Part Number

3) Serial Number and Date Code

f. Set-up screen providing:

1) View set-up

2) Edit set-up

3) Login

4) Logout

2.5 SOURCE QUALITY CONTROL

A. Furnish shop inspection and testing in accordance with NEMA PB 2.

B. Make completed switchboard available for inspection at manufacturer's factory prior to packaging for shipment. Notify LAWA at least seven days before inspection is allowed.

C. Allow witnessing of factory inspections and tests at manufacturer's test facility. Notify LAWA at least seven days before inspections and tests are scheduled.

2.6 EQUIPMENT ENCLOSURES

A. Indoor Enclosures: Steel, NEMA 250, Type 1. Enclosure Finish for Indoor Units: Factory-applied enamel finish in manufacturer's ANSI 61 gray finish over a rust-inhibiting primer on treated metal surface. Finish shall have documented withstand to 600 hours of salt spray test.

B. Outdoor Enclosures: Type 3R or Type 3R Stainless Steel as required per plan drawings

1. Finish: Factory-applied finish in manufacturer's ANSI 61 color; undersurfaces treated with corrosion-resistant undercoating.

2. Enclosure: Flat roof; for each section, with provisions for padlocking.

3. Doors: Personnel door at each end of aisle, minimum width of 30 inches; opening outwards; with panic hardware and provisions for padlocking.

4. Accessories: a set of two keys for each switchboard provided.

5. Factory-installed electric unit heater(s), wall or ceiling mounted, with integral thermostat and disconnect and with capacities to maintain switchboard interior temperature of 40 deg F with outside design temperature of 104 deg F.

2.7 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers

2.8 Equipment enclosures

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with NEMA PB 2.1.

B. Tighten accessible bus connections and mechanical fasteners after placing switchboard.

C. Install engraved nameplates.

D. Install breaker circuit directory.

E. Ground and bond switchboards.

3.2 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Perform inspections and tests listed in NETA ATS, Section 7.1.

3.3 ADJUSTING

A. Adjust operating mechanisms for free mechanical movement.

B. Tighten bolted bus connections.

C. Adjust circuit breaker trip and time delay settings to values as indicated on short circuit study. Refer to Overcurrent Protective Device Coordination Study.

D. These above adjustments shall be performed by a third party. These adjustments shall include but are not limited to, the following studies: short circuit study, coordination study and arc flash study.

END OF SECTION

# SECTION 26 24 16
# PANELBOARDS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes distribution and branch circuit panelboards.

B. For all panelboards above 800A, use switchboards.

C. Related Sections: Division 26 Series.

### 1.2 REFERENCES

A. Institute of Electrical and Electronics Engineers:

1. IEEE C62.41 - Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.

B. National Electrical Manufacturers Association:

1. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.

2. NEMA FU 1 - Low Voltage Cartridge Fuses.

3. NEMA ICS 2 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC.

4. NEMA ICS 5 - Industrial Control and Systems: Control Circuit and Pilot Devices.

5. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

6. NEMA PB 1 - Panelboards.

7. NEMA PB 1.1 - General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less.

C. International Electrical Testing Association:

1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

D. National Fire Protection Association:

1. NFPA 70 - National Electrical Code.

E. Underwriters Laboratories Inc.:

1. UL 67 - Safety for Panelboards.

2. UL 1283 - Electromagnetic Interference Filters.

3. UL 1449 3rd Edition – Surge Protective Devices (SPD)_.

1.3 SUBMITTALS

A. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, integrated short circuit ampere rating, circuit breaker and fusible switch arrangement and sizes.

B. Product Data: Submit catalog data showing specified features of standard products.

1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of panelboards and record actual circuiting arrangements.

B. Operation and Maintenance Data: Submit spare parts listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum five years documented experience.

B. The manufacturer of the panelboard shall be the same manufacturer of the major components within the assembly, including circuit breakers and fusible switches.

C. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of the California Building Code (CBC) through Site Classification D. Guidelines for the installation consistent with these requirements shall be provided by the switchgear manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, CBC: a peak of 2.15g's, and a ZPA of 0.86g's applied at the base of the equipment. The tests shall fully envelop this response spectrum for all equipment natural frequencies up to at least 35 Hz.

D. The following minimum mounting and installation guidelines shall be met, unless specifically modified by the above referenced standards.

E. The Contractor shall provide equipment anchorage details, coordinated with the equipment mounting provision, prepared and stamped by a licensed civil engineer in the state. Mounting

recommendations shall be provided by the manufacturer based upon approved shake table tests used to verify the seismic design of the equipment.

F. The equipment manufacturer shall certify that the equipment can withstand, that is, function following the seismic event, including both vertical and lateral required response spectra as specified in above codes.

G. The equipment manufacturer shall document the requirements necessary for proper seismic mounting of the equipment. Seismic qualification shall be considered achieved when the capability of the equipment, meets or exceeds the specified response spectra.

1.6 MAINTENANCE MATERIALS

A. Furnish two of each panelboard key. Panelboards keyed alike to LAWA's current keying system.

PART 2 - PRODUCTS

2.1 DISTRIBUTION PANELBOARDS

A. Due to the corrosive exterior environment at the airport, all panelboards are to be located indoors, as much as possible. In the event that an exterior installation is the only option, all exterior panelboards are to be a NEMA Type 4X Stainless Steel or better.

B. Manufacturers:

1. Cutler-Hammer/Eaton.

2. GE Electrical.

3. Square D.

C. Product Description: NEMA PB 1, circuit breaker type panelboard.

D. Panelboard Bus: Copper, current carrying components, and furnish copper ground bus in each panelboard.

E. Minimum integrated short circuit rating: Amperes rms symmetrical shall be 42,000A rms symmetrical. Panelboards shall be fully rated; series rated equipment is not acceptable. The short circuit rating of the equipment shall exceed 130% of the available short circuit current at the equipment.

F. Molded Case Circuit Breakers: NEMA AB 1, circuit breakers with integral thermal and instantaneous magnetic trip in each pole. Furnish circuit breakers UL listed as Type HACR for air conditioning equipment branch circuits.

G. Circuit Breaker Accessories: Trip units and auxiliary switches.

H. Enclosure: NEMA PB 1, Type 1 ANSI 61 color-factory applied enamel for indoors, Type 4X Stainless Steel, or better for outdoors.

I. Cabinet Front: Surface door-in-door type, fastened with screws, hinged door with flush lock, metal directory frame, finished in manufacturer's ANSI 61 gray enamel – NC16.

## 2.2 BRANCH CIRCUIT PANELBOARDS

A. Manufacturers:

1. Cutler-Hammer/Eaton.

2. GE Electrical.

3. Square D.

B. Product Description: NEMA PB1, circuit breaker type, lighting and appliance branch circuit panelboard.

C. Panelboard Bus: Copper, current carrying components. Furnish copper ground bus in each panelboard with full sized neutral; furnish insulated ground bus.

D. For non-linear load applications subject to harmonics furnish 200 percent rated, plated copper, solid neutral.

E. Minimum Integrated Short Circuit Rating: 10,000 amperes rms symmetrical for 208 volt panelboards; 14,000 amperes min, rms symmetrical for 480 volt panelboards. Panelboards shall be fully rated; series rated equipment is not acceptable. The shirt circuit rating of the equipment shall exceed 130% of the available short circuit current at the equipment.

F. Molded Case Circuit Breakers: NEMA AB 1, bolt-on type thermal magnetic trip circuit breakers, with common trip handle for all poles, Type HACR for air conditioning equipment circuits, Class A ground fault interrupter circuit breakers. Do not use tandem circuit breakers.

G. Enclosure: NEMA PB 1, Type 1 or for indoor, or NEMA 4 or better for outdoors.

H. Cabinet Box: 6 inches deep, 20 inches inches wide for 240 volt and less panelboards, 20 inches inches wide for 480 volt panelboards. Surface mounted.

I. Cabinet Front: Flush or Surface cabinet, concealed hinge, metal directory frame, and flush lock keyed alike. Finish in manufacturer's standard gray enamel. No concealed trim clamps.

J. Where indicated on the plan drawings or in the plan notes, provide branch circuit monitoring for panelboard branch circuits. The entire system shall be certified by the California Weights and Measures Department and be listed on the State Certified website list:

1. Supply a UL listed microprocessor-based Branch Circuit Monitoring System (PXBCM). This system shall consist of meter base, and meter module(s) as described below

    a. The Branch Circuit Monitor shall measure for up to 84 branch load circuits. Measurements shall include:

        1) Forward and Reverse kWh

        2) Watts, VA, Amps, Power Factor

        3) Present and Peak demand readings for Amps, Forward and Reverse Watts

        4) Maximum Watts, VA, Amps

    b. The Branch Circuit Monitor shall support alarms for current that can be set based on percent of Breaker Rating and alarms for voltage based on percent of nominal voltage.

        1) High, High-High, Low, Low-Low non-latching alarms for current.

        2) High and Low latching alarms for current, resettable via Modbus or the WEB interface

        3) High and Low latching and non-latching voltage alarms for each meter module input voltage.

        4) Alarm Status and alarm counters shall be available via Modbus communications

        5) Branch Circuit monitor shall support upgradeable firmware via communications.

    c. The Branch Circuit Monitor shall have the following ratings

        1) EMC (Electromagnetic Compatibility)

        2) IEC61326: EMI IEC61000-4-X level 3

        3) CISPR 11: Class B emissions, CISPR 22 (Ethernet) class B emissions

        4) FCC part 15 Class B emissions

        5) UL/cUL 61010-1 3rd edition

        6) EN61010-1

d. PXBCM Meter Base

1) Each PXBCM-MB Meter Base shall support connection of up to 4 Meter Modules in either a MMS Strip or MME External configuration monitoring a total of up to 100 single-phase two-wire AC loads, 48 single-phase three-wire AC loads or 32 three-phase four-wire AC loads or combinations not to exceed 25 poles per meter module.

2) The PXBCM-MB shall be equipped with 4 meter module ports. Each port shall provide control power and communications to either a PXBCM-MMS Meter Module Strip or a PXBCM-MME Meter Module External with a maximum cable length of 28ft between each Meter Base and each Meter Module.

3) Each PXBCM-MB shall support connection to up to 4 PXBCM-MMS Meter Module Strip or 4 PXBCM-MME Meter Module External, or a combination of up to 4 total PXBCM-MMS and PXBCM-MME each meter module with independent single or three phase voltage metering circuits with inputs up to 277V L-N and 480V L-L.

4) PXBCM-MB Power Supply shall be rated for 100-277VAC L:N +/-10% CAT III, 47-63 Hz , 6W

5) The PXBCM-MB shall include an 3 terminal RS-485 serial port for Modbus RTU communications and an RJ-45 port for Ethernet communications. The Ethernet port shall support Modbus TCP communications as well as an Embedded WEB server.

6) The PXBCM-MB embedded WEB server shall support device configuration for to up to 4 PXBCM-MMS Meter Module Strip or 4 PXBCM-MME Meter Module External, or a combination of up to 4 total PXBCM-MMS and PXBCM-MME and display of up to 100 points of metering data. It shall be possible to save device configuration information to a file for archiving and for uploading to PXBCMs.

7) The PXBCM-MB shall support connection to a pre-configured HMI via RS-485 serial port. The HMI shall not require configuration

8) The PXBCM-MB shall be equipped with LED’s to indicate comms, Device/Alarm Status, DHCP/Fixed IP

9) The PXBCM-MB shall be equipped with 2 rotary switches to assign Modbus Slave ID 1-99.

10) The PXBCM-MB shall be equipped with mode switches to set device security mode

11) The PXBCM Meter Base shall automatically sense the type of PXBCM Meter Module connected to each of its 4 meter module ports.

12) The Configuration wizard shall support naming and configuration of up 100 virtual meters by assigning 1-3 channels of current to 1, 2 or 3 pole meters. Virtual meters shall aggregate the channel data assigned to each virtual meter and report the aggregated virtual meter values for:

a) Forward and Reverse Energy

b) Watts, VA, Average Amps and Power Factor

c) Average and Peak demand for Watts and VA

e. PXBCM-MMS Meter Module Strip

1) PXBCM-MMS Meter Module Strips shall be available in configurations to mount on either the left or right of a panelboard and shall have option of 9, 15, or 21 CTs. Four additional 333mV connections shall be provided on each PXBCM-MMS for Auxiliary 333mV CT connections which can be used to monitor the panel mains or branch circuits. The MMS shall include both load current and voltage metering circuits providing meter data to the Meter Base.

2) The PXBCM Meter Module Strip shall be available with either 9 CT's, 15 CT's or 21 CT's per assembly for factory assembly into Panelboards with 18, 30 or 42 poles. PXBCM MMS CT's shall have be rated for up to 100A continuous current monitoring and designed to mount in an Eaton PRL-1a, PRS-2a or PRL-3e Panelboard with 1 inch breaker pole spacing.

3) PXBCM Meter Module Strip 1 inch center CTs shall have a window opening sufficient for insulated Aluminum conductor rated for 100A capacity

4) The PXBCM Meter Module Strip shall support direct connection of one set of 3 phase nominal metering voltage inputs up to 277V L-N and 480V L-L voltages and shall be rated as Cat III.

5) The Meter Modules can also monitor voltage in the following configurations:

a) Three Phase, four wire wye

b) Three phase, three wire delta

c) Three phase, center tapped delta

d) Three phase, three wire

e) Single phase, two wire

6) Power and Energy metering shall be performed based on the voltage assignment for each 100A strip mounted CT and 333mV Aux CT current input as configured using the embedded WEB server.

7) PXBCM MMS Accuracy of kWh metering on branch circuits shall be rated for ANSI C12.20 0.5 accuracy class as a system, including 100A rated strip mounted solid core current transformers. kWh accuracy for 333mV input auxiliary circuits shall satisfy ANSI C12.20 0.5 class excluding external 333mV sensor performance.

8) The PXBCM MMS shall be UL approved for mounting to the panelboard interior with no interference. Strip placement shall line up 1 inch center CT's with breaker poles and not impede the normal routing of branch circuit conductors in the panel enclosure.

9) The PXBCM MMS shall connect to the PXBCM MB using factory supplied cables.

f. PXBCM-MME Meter Module External

1) The PXBCM-MME provides the same metering functionality as the PXBCM-MMS but is used for retrofit or non-uniform/high-mix load applications where the PXBCM-MMS strip mounted 100A CT's cannot be applied.

2) The PXBCM Meter Module external shall support 25 channels of current using external 333mV current sensors connected to terminal strips on the PXBCM-MME.

3) The PXBCM Meter Module External shall support direct connection of one set of 3 phase nominal metering voltage inputs up to 277V L-N and 480V L-L voltages and shall be rated as Cat III.

4) The Meter Modules can also monitor voltage in the following configurations:

a) Three Phase, four wire wye

b) Three phase, three wire delta

c) Three phase, center tapped delta

d) Three phase, three wire

e) Single phase, two wire

5) Power and Energy metering shall be performed based on the voltage assignment for each 333mV current sensor input as configured using the embedded WEB server.

6) PXBCM MMS Accuracy of kWh metering on 333mV input circuits shall satisfy ANSI C12.20 0.5 class excluding external 333mV sensor performance.

g. Optional HMI Display shall display data for all configured sub-meters.

1) HMI configuration shall not be required for each sub-meter. The HMI shall discover the configuration information automatically.

2) Displayed information shall include;

a) Sub-meter name, current, voltage, energy consumption, demand, and power factor for up to 100 load circuits. Aggregated Power and Energy readings for any 1, 2 or 3 pole meters.

## 2.3 ELECTRONIC-GRADE PANELBOARDS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

3. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1; with factory-installed, integral TVSS; labeled by an NRTL for compliance with UL 67 after installing TVSS.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

D. Main Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.

E. Branch Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.

F. Buses:

1. Copper phase and neutral buses; 200 percent capacity neutral bus and lugs.

2. Copper equipment and isolated ground buses.

G. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, plug-in, solid-state, parallel-connected, modular with field-replaceable modules type, with sine-wave tracking suppression and filtering modules, short-circuit current rating complying with UL 1449, third edition, and matching or exceeding the panelboard short-circuit rating, redundant suppression circuits, with individually fused metal-oxide varistors.

1. Accessories:

a. Fuses rated at 200-kA interrupting capacity.

b. Fabrication using bolted compression lugs for internal wiring.

c. Integral disconnect switch.

d. Redundant suppression circuits.

e. Redundant replaceable modules.

f. Arrangement with wire connections to phase buses, neutral bus, and ground bus.

g. LED indicator lights for power and protection status.

h. Audible alarm, with silencing switch, to indicate when protection has failed.

i. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

j. Six-digit, transient-event counter set to totalize transient surges.

2. Peak Single-Impulse Surge Current Rating: 120 kA per model/240 kA 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: 70,000A.

b. Line to Ground: 70,000 A.

c. Neutral to Ground: 50,000 A.

4. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.

5. Protection modes and UL 1449 SVR for grounded wye circuits with **480Y/277** or **208Y/120** -V, three-phase, four-wire circuits shall be as follows:

a. Line to Neutral: 800 V for 480Y/277.

b. Line to Ground: 800 V for 480Y/277.

c. Neutral to Ground: 800 V for 480Y/277.

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

a. Line to Neutral: 400 V.

b. Line to Ground: 400 V.

c. Neutral to Ground: 400 V.

7. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-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.

8. Protection modes and UL 1449 SVR for 240-, 480-,, three-phase, three-wire, delta circuits shall be as follows:

a. Line to Line: 2000 V for 480 V.

b. Line to Ground: 1500 V for 480 V.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install panelboards in accordance with NEMA PB 1.1.

B. Install panelboards plumb.

C. Install recessed panelboards flush with wall finishes.

D. Height: 6 feet to top of panelboard; install panelboards taller than 6 feet with bottom no more than 4 inches above floor.

E. Install filler plates for unused spaces in panelboards.

F. Provide typed circuit directory for each branch circuit panelboard. Refer to LAWA standard before revising directory to reflect circuiting changes to balance phase loads.

G. Install engraved nameplates per LAWA standards.

H. Install spare conduits out of each recessed panelboard to accessible location above ceiling or below floor. Minimum spare conduits: 5 empty 1 inch. Identify each as SPARE.

I. Ground and bond panelboard enclosure. Connect equipment ground bars of panels in accordance with NFPA 70.

## 3.2 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Perform circuit breaker inspections and tests listed in NETA ATS, Section 7.6.

C. Perform switch inspections and tests listed in NETA ATS, Section 7.5.

D. Perform controller inspections and tests listed in NETA ATS, Section 7.16.1.

END OF SECTION

# SECTION 26 24 19
# MOTOR-CONTROL CENTERS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes motor control centers.

### 1.2 REFERENCES

A. Institute of Electrical and Electronics Engineers:

1. IEEE C62.41 - Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.

B. National Electrical Manufacturers Association:

1. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.

2. NEMA FU 1 - Low Voltage Cartridge Fuses.

3. NEMA ICS 2 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC.

4. NEMA ICS 2.3 - Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers.

5. NEMA ICS 3 - Industrial Control and Systems: Factory Built Assemblies.

6. NEMA ICS 5 - Industrial Control and Systems: Control Circuit and Pilot Devices.

7. NEMA ICS 7 - Industrial Control and Systems: Adjustable Speed Drives.

8. NEMA ICS 7.1 - Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable Speed Drive Systems.

9. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

C. International Electrical Testing Association:

1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

### 1.3 SUBMITTALS

A. Shop Drawings: Indicate front and side views of enclosures with overall dimensions shown; conduit entrance locations and requirements; nameplate legends; size and number of bus bars for each phase, neutral, and ground; electrical characteristics including voltage, frame size and trip ratings, withstand ratings, and time and current curves of equipment and components.

B. Product Data: Submit electrical characteristics including voltage, frame size and trip ratings, fault current withstand ratings, and time-current curves of equipment and components.

C. Submit dimensioned room layout complete with all equipment shown to scale.

D. Submit control schematics for each starter within.

E. The electrical contractor shall submit ¼”=1’0” scale sketches of all electrical rooms and areas including actual dimensions of all equipment in electrical rooms and indicate clearances per NEC, as well as door swings or other obstacles. Sketches shall be submitted along with or prior to shop drawing submittals. Shop drawing submittal without sketches shall be returned and not reviewed.

1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations, configurations, and ratings of motor control centers and major components.

B. Operation and Maintenance Data: Submit replacement parts list for controllers.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum five years documented experience.

PART 2 - PRODUCTS

2.1 MOTOR CONTROL CENTER

A. Manufacturers:

1. Cutler-Hammer.

2. GE Electrical.

3. Square D.

B. Product Description: NEMA ICS 3, Class I, Type B heavy duty, industrial grade motor control center.

C. Service Conditions: NEMA ICS 2.

D. Main Overcurrent Protection: Molded case circuit breaker.

E. Feeder Tap Units: Molded case thermal-magnetic circuit breakers.

F. Voltage Rating: 480 or 120/208 volts, three phase, three or four wire, 60 Hertz.

G. Horizontal Bus: Copper, with continuous current rating. Include copper ground bus entire length of control center.

H. Vertical Bus: Copper.

I. Configuration: Units front mounting only, accessible from front only.

J. Enclosure: NEMA ICS 6, Type 1 or 4, non-walk-in or 4, walk-in or 12.

K. Finish: Manufacturer's standard gray enamel.

L. All indicating and pilot lights shall be LED with metal housing and easily replaceable parts.

M. All control wiring shall be installed in Panduit wiring ducts. Control wiring shall be stranded copper.

## 2.2 FULL-VOLTAGE NON-REVERSING CONTROLLERS

A. Manufacturers:

1. Cutler-Hammer.

2. GE Electrical.

3. Square D.

B. Product Description: NEMA ICS 2, AC general-purpose Class A magnetic controller for induction motors rated in horsepower.

C. Overload Relay: NEMA ICS 2; bimetal or melting alloy.

D. Product Options and Features:

1. Auxiliary Contacts: NEMA ICS 2, 2 each field convertible contacts in addition to seal-in contact.

2. Cover Mounted Pilot Devices: NEMA ICS 5, heavy duty type.

3. Pilot Device Contacts: NEMA ICS 5, Form Z, rated A150.

4. Pushbuttons: Unguarded type.

5. Indicating Lights: LED type.

6. Selector Switches: Rotary type, Hand-Off-Auto.

7. Relays: NEMA ICS 5.

8. Control Power Transformers: In each motor controller as scheduled. Furnish fused primary and secondary, and bond unfused leg of secondary to enclosure.

## 2.3 TWO-SPEED CONTROLLERS

A. Manufacturers:

1. Cutler-Hammer.

2. GE Electrical.

3. Square D.

B. Product Description: NEMA ICS 2, AC general-purpose Class A magnetic controller for induction motors rated in horsepower. Include integral time delay transition between FAST and SLOW speeds.

C. Control Voltage: As required.

D. Overload Relay: NEMA ICS 2; bimetal or melting alloy.

E. Product Options and Features:

1. Auxiliary Contacts: NEMA ICS 2, 2 each field convertible contacts in addition to seal-in contact.

2. Cover Mounted Pilot Devices: NEMA ICS 5, heavy duty type.

3. Pilot Device Contacts: NEMA ICS 5, Form Z, rated A150.

4. Pushbuttons: Unguarded type.

5. Indicating Lights: LED type.

6. Selector Switches: Rotary type, with “High-Low”.

7. Relays: NEMA ICS 5.

8. Control Power Transformers: In each motor controller as scheduled. Furnish fused primary and secondary, and bond unfused leg of secondary to enclosure.

## 2.4 FULL-VOLTAGE REVERSING CONTROLLERS

A. Manufacturers:

1. Cutler-Hammer.

2. GE Electrical.

3. Square D.

B. Product Description: NEMA ICS 2, AC general-purpose Class A magnetic controller for induction motors rated in horsepower. Include electrical interlock and integral time delay transition between FORWARD and REVERSE rotation.

C. Control Voltage: As required.

D. Overload Relay: NEMA ICS 2; bimetal or melting alloy.

E. Product Options and Features:

1. Auxiliary Contacts: NEMA ICS 2, 2 each field convertible contacts in addition to seal-in contact.

2. Cover Mounted Pilot Devices: NEMA ICS 5, heavy duty type.

3. Pilot Device Contacts: NEMA ICS 5, Form Z, rated A150.

4. Pushbuttons: Unguarded type.

5. Indicating Lights: LED type.

6. Selector Switches: Rotary type.

7. Relays: NEMA ICS 5.

8. Control Power Transformers: In each motor controller as scheduled. Furnish fused primary and secondary, and bond unfused leg of secondary to enclosure.

## 2.5 MOLDED CASE CIRCUIT BREAKER

A. Manufacturers:

1. Cutler-Hammer.

2. GE Electrical.

3. Square D.

B. Product Description: NEMA AB 1, molded-case circuit breaker.

C. Field-Adjustable Trip Circuit Breaker: Circuit breakers with frame sizes 200 amperes and larger have mechanism for adjusting long time, short time, continuous current and long time pickup current setting for automatic operation.

2.6 SOURCE QUALITY CONTROL

A. Shop, inspect and perform standard productions tests for each controller in accordance with manufacturer's standards.

B. Make completed motor control center available for inspection at manufacturer's factory prior to packaging for shipment. Notify LAWA at least seven days before inspection is allowed.

C. Allow witnessing of factory inspections and tests at manufacturer's test facility. Notify LAWA at least seven days before inspections and tests are scheduled.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify surfaces are suitable for motor control center installation.

3.2 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Perform inspections and tests listed in NETA ATS, Section 7.16.

C. Inspect and test variable frequency controllers according to NEMA ICS 7.1.

3.3 INSTALLATION

A. Install engraved nameplates.

B. Neatly type label inside each motor controller door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, voltage rating, and phase rating. Place label in clear plastic holder.

C. Ground and bond motor control centers.

D. Provide wire markers or tags for all control wiring at all termination points. See Identification for Electrical Systems.

E. Each plug-in unit shall control only one motor, no dual starters.

F. Provide a circuit breaker for the unit disconnect device, not a fusible switch.

G. Provide side mounted, latched pull-apart terminal blocks for all remote control wiring. Provide 25% spare terminals.

H. No interlock for A-B motor configuration.

I. Overload reset button shall be operable without wires blocking access.

END OF SECTION

# SECTION 26 25 00
# ENCLOSED BUS ASSEMBLIES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes busway and fittings.

### 1.2 REFERENCES

A. Institute of Electrical and Electronics Engineers:

1. IEEE C62.41 - Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.

B. National Electrical Manufacturers Association:

1. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.

2. NEMA BU 1 - Busways.

3. NEMA BU 1.1 - General Instructions for Proper Handling, Installation, Operation, and Maintenance of Busway Rated 600 Volts or Less.

4. NEMA FU 1 - Low Voltage Cartridge Fuses.

5. NEMA ICS 2 - Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC.

6. NEMA ICS 5 - Industrial Control and Systems: Control Circuit and Pilot Devices.

7. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

C. International Electrical Testing Association:

1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

### 1.3 SUBMITTALS

A. Shop Drawings: Indicate ratings, dimensions and finishes. Include dimensioned layout diagram; installation details; locations of supports and fittings; and firestops and weatherseals at penetrations. Include details of wall and floor penetrations. Include isometric layouts/views of

bus duct configuration.

B. Product Data: Submit catalog data for components.

C. Coordination Drawings: Indicate busway layout and support locations.

1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of busway routing.

B. Operation and Maintenance Data: Submit joint re-tightening schedule.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum five years documented experience.

B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.

C. All busway components shall be of the same manufacturers as the busway.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Handle in accordance with NEMA BU 1.1 and manufacturer's written instructions.

B. Protect from moisture by using appropriate coverings. Store in dry interior locations.

1.7 ENVIRONMENTAL REQUIREMENTS

A. Do not install indoor busway until building is closed in and suitable temperature conditions are controlled.

B. Conform to NEMA BU 1 service conditions during and after installation of busway.

1.8 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.9 SEQUENCING

A. Sequence Work to avoid interferences with building finishes and installation of other products.

PART 2 - PRODUCTS

2.1 BUSWAY

A. Manufacturers:

1. Cutler Hammer.

2. General Electric.

3. Square D.

B. Product Description: NEMA BU1, 3 phase, 4wire enclosed busway. Indoor: Sprinkler proof. Outdoor; NEMA 4. Feeder type or plug-in type as applicable or as required.

1. Voltage: 277/480 volts, 60 Hz, or as required.

2. Ampere Ratings: As required.

3. Full neutral.

4. Insulated ground bus.

C. Conductors: Copper bars, fully insulated except at joints.

D. Joints: Single bolt type, with silver-plated contact surface for bus and splice plate.

E. Fittings: According to manufacturer's recommendations.

F. Finish: Manufacturer's standard gray enamel.

2.2 SOURCE QUALITY CONTROL

A. Inspect and test according to NEMA BU1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with NEMA BU1.1.

B. Tighten joints using torque wrench, to manufacturer's specified values.

C. Install busway length with expansion fitting at each location where busway run crosses building expansion joint.

D. Support busway at maximum 10 feet intervals or as recommended by manufacturer. Support vertical riser at each floor.

E. Install busway with integral fire stops located where busway penetrates fire-rated walls and floors. Seal around opening to maintain fire-rating equal to wall or floor rating.

F. Install concrete curb around interior floor penetrations.

G. Install engraved nameplates.

H. Ground and bond busway.

3.2 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Perform inspections and tests listed in NETA ATS, Section 7.4.

END OF SECTION

# SECTION 26 27 16
# ELECTRICAL CABINETS AND ENCLOSURES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes hinged cover enclosures, cabinets, terminal blocks, and accessories.

### 1.2 REFERENCES

A. National Electrical Manufacturers Association:

1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

2. NEMA ICS 4 - Industrial Control and Systems: Terminal Blocks.

### 1.3 SUBMITTALS

A. Product Data: Submit manufacturer's standard data for enclosures, cabinets, and terminal blocks.

B. Manufacturer's Installation Instructions: Submit application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

### 1.4 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.

### 1.5 EXTRA MATERIALS

A. Furnish two of each key.

## PART 2 - PRODUCTS

2.1 Due to the corrosive exterior environment at the airport, <u>all</u> electrical cabinets and enclosures are to be located indoors, as much as possible. In the event that an exterior installation is the only option, these items are to be a NEMA Type 4x – Stainless Steel.

### 2.2 HINGED COVER ENCLOSURES

A. Manufacturers:

1. Hoffman Electrical Products.

2. Square D

3. General Electric

B. Construction: NEMA 250, Type 1 for indoors or 4X stainless steel enclosure for outdoor installations.

C. Covers: Continuous hinge, held closed by flush latch operable by key.

D. Furnish interior plywood panel for mounting terminal blocks and electrical components; finish with white enamel.

E. Enclosure Finish: Manufacturer's standard enamel.

## 2.3 CABINETS

A. Manufacturers:

1. Hoffman Electrical Products.

2. Square D.

3. General Electric.

B. Boxes: Galvanized steel with removable end walls.

C. Backboard: Furnish 3/4 inch thick plywood backboard for mounting terminal blocks. Paint matte white.

D. Fronts: Steel, flush or surface type with screw cover front, door with concealed hinge. Finish with gray baked enamel.

E. Knockouts: as required for conduit entry.

F. Furnish metal barriers to form separate compartments wiring of different systems and voltages.

G. Furnish accessory feet for free-standing equipment.

## 2.4 TERMINAL BLOCKS

A. Terminal Blocks: NEMA ICS 4.

B. Power Terminals: Unit construction type with closed back and tubular pressure screw connectors, rated 600 volts.

C. Signal and Control Terminals: Modular construction type, suitable for channel mounting, with

tubular pressure screw connectors, rated 300 volts.

D. Furnish ground bus terminal block, with each connector bonded to enclosure.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install enclosures and boxes plumb. Anchor securely to wall and structural supports at each corner.

B. Install cabinet fronts plumb.

### 3.2 CLEANING

A. Clean electrical parts to remove conductive and harmful materials. B. Remove dirt and debris from enclosure.

C. Clean finishes and touch up damage.

END OF SECTION

# SECTION 26 27 26
# WIRING DEVICES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes wall switches; wall dimmers; receptacles; multi-outlet assembly; and device plates and decorative box covers.

B The colors for all new wiring devices shall be compatible with the interior design aesthetic established for the public areas of the terminal. Section includes wall switches; wall dimmers; receptacles; multi-outlet assembly; and device plates and decorative box covers.

### 1.2 REFERENCES

A. National Electrical Manufacturers Association:

1. NEMA WD 1 - General Requirements for Wiring Devices.

2. NEMA WD 6 - Wiring Devices-Dimensional Requirements.

### 1.3 SUBMITTALS

A. Product Data: Submit manufacturer's catalog information showing dimensions, colors, and configurations.

B. Samples: Submit two samples of each wiring device and wall plate illustrating materials, construction, color, and finish.

### 1.4 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three year’s experience.

### 1.5 EXTRA MATERIALS

A. Furnish two of each style, size, and finish wall plate.

## PART 2 - PRODUCTS

### 2.1 WIRING DEVICES

A. All wiring devices for emergency circuits shall be red.

2.2 WALL SWITCHES

A. Manufacturers:

1. Leviton.

2. Hubbell.

3. Pass and Seymour.

B. Product Description: NEMA WD 1 Industrial, Heavy-Duty, AC only general-use snap switch, Leviton Decora, or similar.

C. Indicator Light: Lighted handle type switch.

D. Locator Light: Lighted handle type switch; clear color handle.

E. Ratings:

1. Voltage: 120-277 volts, AC.

2. Current: 20 amperes.

2.3 WALL DIMMERS

A. Manufacturers:

1. Hubbell.

2. Leviton.

3. Lutron.

B. Product Description: NEMA WD 1, Type I semiconductor dimmer for incandescent lamps and for fluorescent lamps. Coordinate ballast type with dimmable fluorescent lamps.

C. Voltage: 120V or as required for application.

D. Power Rating: As required for application.

E. Accessory Wall Switch: Match dimmer appearance.

2.4 RECEPTACLES

A. Manufacturers:

1. Hubbell.

2. Leviton.

3. Pass and Seymour.

B. Product Description: NEMA WD 1, industrial, Heavy-duty and general-duty general-use receptacle, Leviton Decora or similar.

C. Configuration: NEMA WD 6, type as required.

D. Convenience Receptacle: Type 5-20.

E. GFCI Receptacle: Convenience receptacle with integral ground fault circuit interrupter to meet regulatory requirements.

2.5 WALL PLATES

A. Manufacturers:

1. Hubbell.

2. Pass and Seymour.

3. Leviton.

B. Indoor Cover Plate: Stainless Steel, for indoor switches, dimmers and receptacles.

C. Weatherproof Cover Plate: Gasketed cast metal plate with hinged and gasketed device cover for outdoor wiring devices.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify outlet boxes are installed at proper height.

B. Verify wall openings are neatly cut and completely covered by wall plates.

C. Verify branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

3.2 PREPARATION

A. Clean debris from outlet boxes.

## 3.3 INSTALLATION

A. Install devices plumb and level.

B. Install switches with OFF position down.

C. Install wall dimmers to achieve full rating specified and indicated after derating for ganging as instructed by manufacturer.

D. Do not share neutral conductor on load side of dimmers.

E. Install receptacles with grounding pole on top.

F. Connect wiring device grounding terminal to branch circuit equipment grounding conductor.

G. Install cover plates on switch, dimmer, receptacle, and blank outlets in all areas.

H. Connect wiring devices by wrapping solid conductor around screw terminal. Install stranded conductor for branch circuits 10 AWG and smaller. When stranded conductors are used in lieu of solid-use crimp-on fork terminals for device terminations. Do not place bare stranded conductors directly under device screws.

1. Use jumbo size plates for outlets installed in masonry walls.

I. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas and above accessible ceilings.

J. Label all plugs and switch with source power and circuit number with P-Touch label maker using Ariel Font, Size 12.

## 3.4 INTERFACE WITH OTHER PRODUCTS

A. Coordinate locations of outlet boxes to obtain required mounting heights.

B. Install wall switch 48 inches above finished floor, unless otherwise noted.

C. Install convenience receptacle 18 inches above finished floor, unless otherwise noted.

D. Install convenience receptacle 6 inches above back splash of counter.

E. Install dimmer 48 inches above finished floor, unless otherwise noted.

## 3.5 FIELD QUALITY CONTROL

A. Inspect each wiring device for defects.

B. Operate each wall switch with circuit energized and verify proper operation.

C. Verify each receptacle device is energized.

D. Test each receptacle device for proper polarity.

E. Test each GFCI receptacle device for proper operation.

3.6 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

3.7 CLEANING

A. Clean exposed surfaces to remove splatters and restore finish.

END OF SECTION

# SECTION 26 28 13
# FUSES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes fuses.

### 1.2 REFERENCES

A. National Electrical Manufacturers Association:

1. NEMA FU 1 - Low Voltage Cartridge Fuses.

### 1.3 DESIGN REQUIREMENTS

A. Select fuses to provide appropriate levels of short circuit and overcurrent protection for the following components: wire, cable, bus structures, and other equipment. Design system to maintain component damage within acceptable levels during faults.

B. Select fuses to coordinate with time current characteristics of other overcurrent protective elements, including other fuses, circuit breakers, and protective relays. Design system to maintain operation of device closest to fault operates.

### 1.4 FUSE PERFORMANCE REQUIREMENTS

A. Motor Load Feeder Switches: Class RK1 (time delay).

B. General Purpose Branch Circuits: Class RK1 (time delay).

C. Motor Branch Circuits: Class RK1 (time delay).

### 1.5 SUBMITTALS

A. Product Data: Submit data sheets showing electrical characteristics, including time-current curves.

### 1.6 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual sizes, ratings, and locations of fuses.

### 1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

1.8 MAINTENANCE MATERIALS

A. Furnish two fuse pullers for each type of fuses.

PART 2 - PRODUCTS

2.1 FUSES

A. Manufacturers:

1. Bussman

2. Gould.

3. Littlefuse.

B. Dimensions and Performance: NEMA FU 1, Class as required.

C. Voltage: Rating suitable for circuit phase-to-phase voltage.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fuse with label oriented so manufacturer, type, and size are easily read.

B. Install spare fuse cabinet.

END OF SECTION

# SECTION 26 28 19
# ENCLOSED SWITCHES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes fusible and non-fusible switches.

### 1.2 REFERENCES

A. National Electrical Manufacturers Association:

1. NEMA FU 1 - Low Voltage Cartridge Fuses.

2. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

B. International Electrical Testing Association:

1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

2. Underwriters Laboratory, Inc. (UL).

a. 98 B Enclosed and Dead-Front Switches,

b. 198C B High Interrupting Capacity Fuses, Current Limiting Types.

c. 198E B Class R Fuses.

d. 512 B Fuseholders.

### 1.3 SUBMITTALS

A. Product Data: Submit switch ratings and enclosure dimensions.

B. The electrical contractor shall submit ¼”=1’0” scale sketches of all electrical rooms and areas including actual dimensions of all equipment in electrical rooms and indicate clearances per NEC, as well as door swings or other obstacles. Sketches shall be submitted along with or prior to shop drawing submittals. Shop drawing submittal without sketches shall be returned and not reviewed.

### 1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of enclosed switches and ratings of installed fuses.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCH ASSEMBLIES

A. Manufacturers:

1. General Electric.

2. Cutler Hammer.

3. Square D.

B. Product Description: NEMA KS 1, Type HD, quick-make/quick break with externally operable handle interlocked to prevent opening front cover with switch in ON position, enclosed load interrupter knife switch. Handle lockable in OFF position.

C. Fuse clips: Designed to accommodate NEMA FU 1.

D. Enclosure: NEMA KS 1, to meet conditions. Fabricate enclosure from steel finished with manufacturer's standard gray enamel.

1. Interior Dry Locations: Type 1.

2. Exterior Locations: Type 4 or better.

E. Furnish switches with entirely copper current carrying parts.

2.2 NON-FUSIBLE SWITCH ASSEMBLIES

A. Manufacturers:

1. General Electric.

2. Cutler Hammer.

3. Square D.

B. Product Description: NEMA KS 1, Type HD quick make/quick-break with externally operable handle interlocked to prevent opening front cover with switch in ON position enclosed load interrupter knife switch. Handle lockable in OFF position.

C. Enclosure: NEMA KS 1, to meet conditions. Fabricate enclosure from steel finished with manufacturer's standard gray enamel.

1. Interior Dry Locations: Type 1.

2. Exterior Locations: Type 4 or better.

D. Furnish switches with entirely copper current carrying parts.

## 2.3 SWITCH RATINGS

A. Switch Rating: Number of poles, voltage, current and horsepower rating as required for particular installation.

B. Short Circuit Current Rating: UL listed for 200,000 rms symmetrical amperes when used with or protected by Class R or Class J fuses (30-600 ampere switches employing appropriate fuse rejection schemes).

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Install enclosed switches plumb. Provide supports.

B. Height: 5 feet to operating handle.

C. Install fuses for fusible disconnect switches.

D. Install engraved nameplates.

E. Apply adhesive tag on inside door of each fused switch indicating NEMA fuse class and size installed.

## 3.2 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Perform inspections and tests listed in NETA ATS, Section 7.5.

END OF SECTION

# SECTION 26 28 23
# ENCLOSED CIRCUIT BREAKERS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes molded-case and insulated-case circuit breakers in individual enclosures.

### 1.2 REFERENCES

A. National Electrical Manufacturers Association:

1. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.

B. International Electrical Testing Association:

1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

### 1.3 SUBMITTALS

A. Submit shop drawings after Short Circuit and Overcurrent Protective Device Coordination Study, is approved. Shop drawings submitted without approved study will be returned and not reviewed.

B. AIC ratings shown on the single line diagrams are approximate values only. The AIC ratings of all submitted equipment must conform to the approved Short Circuit and Overcurrent Protective Device Coordination Study.

C. The electrical contractor shall submit ¼”=1’0” scale sketches of all electrical rooms and areas including actual dimensions of all equipment in electrical rooms and indicate clearances per NEC, as well as door swings or other obstacles. Sketches shall be submitted along with or prior to shop drawing submittals. Shop drawing submittal without sketches shall be returned and not reviewed.

D. Product Data: Submit catalog sheets showing ratings, trip units, time current curves, dimensions, and enclosure details.

### 1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations and continuous current ratings of enclosed circuit breakers.

### 1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

## PART 2 - PRODUCTS

### 2.1 MOLDED CASE CIRCUIT BREAKER

A. Manufacturers:

1. General Electric.

2. Cutler Hammer.

3. Square D.

B. Product Description: Enclosed, molded-case circuit breaker conforming to NEMA AB 1 and FS-W-C.

C. Field-Adjustable Trip Circuit Breaker: Circuit breakers with frame sizes 400 amperes and larger have mechanism for adjusting long time, short time, continuous current setting for automatic operation.

D. Field-Changeable Ampere Rating Circuit Breaker: Circuit breakers with frame sizes 200 amperes and larger have changeable trip units.

E. Solid-State Circuit Breaker: Electronic sensing, timing, and tripping circuits for adjustable current settings; ground fault trip with integral ground fault sensing; instantaneous trip; and adjustable short time trip.

F. Accessories: Conform to NEMA AB 1.

1. Accessories will be dependent on the system design.

a. Shunt Trip Device: 120 volts, AC.

b. Undervoltage Trip Device: 120 volts, AC.

c. Auxiliary Switch: 120 volts, AC.

d. Alarm Switch: 120 volts, AC.

e. Electrical Operator: 120 volts, AC.

f. Handle Lock: Provisions for padlocking.

G. Enclosure: NEMA AB 1, to meet conditions. Fabricate enclosure from steel finished with manufacturer's standard gray enamel.

1. Interior Dry Locations: Type 1.

2. Exterior Locations: Type 4 or better.

H. Series Rating: Series rated breakers shall not be used.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Verify that surfaces are ready to receive work.

B. Verify field measurements.

C. Verify that required utilities are available, in proper location and ready for use.

D. Beginning of installation means that installer accepts conditions.

### 3.2 INSTALLATION

A. Install enclosed circuit breakers plumb. Provide supports.

B. Height: 5 feet to operating handle.

C. Locate and install engraved nameplates.

### 3.3 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Perform inspections and tests listed in NETA ATS, Section 7.6.1.1.

### 3.4 ADJUSTING

A. Adjust trip settings to coordinate circuit breakers with other overcurrent protective devices in circuit.

B. Adjust trip settings to provide adequate protection from overcurrent and fault currents.

END OF SECTION

# SECTION 26 28 26
# ENCLOSED TRANSFER SWITCHES

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes transfer switches in individual enclosures.

### 1.2 REFERENCES

A. National Electrical Manufacturers Association:

1. NEMA ICS 10 - Industrial Control and Systems: AC Transfer Switch Equipment.

B. International Electrical Testing Association:

1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

C. Underwriters Laboratories Inc.:

1. UL 1008 - Transfer Switch Equipment.

### 1.3 SUBMITTALS

A. Submit shop drawings after Short Circuit and Overcurrent Protective Device Coordination Study, is approved. Shop drawings submitted without approved study will be returned and not reviewed.

B. AIC ratings shown on the single line diagrams are approximate values only. The AIC ratings of all submitted equipment must conform to the approved Short Circuit and Overcurrent Protective Device Coordination Study.

C. The electrical contractor shall submit scaled sketches of all electrical rooms and areas including actual dimensions of all equipment in electrical rooms and indicate clearances per NEC, as well as door swings or other obstacles. Sketches shall be submitted along with or prior to shop drawing submittals. Shop drawing submittal without sketches shall be returned and not reviewed.

D. Product Data: Submit catalog sheets showing voltage, switch size, ratings and size of switching and overcurrent protective devices, operating logic, control schematics, short circuit ratings, dimensions, and enclosure details.

### 1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of enclosed transfer switches.

B. Operation and Maintenance Data: Submit routine preventative maintenance and lubrication schedule. List special tools, maintenance materials and replacement parts.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience, and with service facilities within 100 miles of Project.

B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.

1.6 MAINTENANCE SERVICE

A. Furnish service and maintenance of transfer switches for one year from Date of Substantial Completion.

PART 2 - PRODUCTS

2.1 AUTOMATIC TRANSFER SWITCH

A. Manufacturers:

1. Russelectic Inc.

2. ASCO.

3. Onan.

B. Manufacturer

1. The combination transfer bypass/isolation switch manufacturer shall employ a nationwide factory-direct, field service organization, available on a 24-hour a day, 365 days a year, call basis.

2. The manufacturer shall maintain records of each combination transfer bypass/isolation switch, by serial number, for a minimum 20 years.

C. Product Description: Automatic transfer switch with by-pass isolation switches.

D. Rating: State voltage and current rating and number of poles.

E. Interrupting Capacity: As required from coordination study.

2.2 CONSTRUCTION

A. General

1. The automatic transfer switch (ATS) and its associated bypass/isolation (BPS) shall be furnished. Voltage and continuous current ratings and number of poles shall be as required.

2. All ATS shall be a true 4-pole switch supplied with all four poles mounted on a common shaft as a 3 pole switch. The continuous current rating and the closing and withstand rating of the fourth pole shall be identical to the rating of the main poles.

3. The combination automatic transfer bypass/isolation switch shall be mounted in a freestanding NEMA 1 enclosure, unless otherwise indicated. Enclosures shall be fabricated from 12-gauge steel. The enclosure shall be sized to exceed minimum wire bending space required by UL 1008.

4. Both units shall be bused together with silver plated copper bus and/or cable interconnection bus to provide a complete pre-tested assembly. Construction shall be such that the contractor needs to install only the power and control connections.

5. Bypass/isolation switches shall provide a safe and convenient means for manually bypassing and isolating the automatic transfer switch, regardless of the condition or position of the ATS, with the ability to be used as an emergency back-up system in the event the transfer switch should fail. In addition, the bypass/isolation switch shall be utilized to facilitate maintenance and repair of the automatic transfer switch.

6. The automatic transfer switch shall be completely isolated from the bypass/isolation switch by means of insulating barriers and separate access doors to positively prevent hazard to operating personnel while servicing the automatic transfer switch.

7. The combination automatic transfer bypass/isolation switch shall be top and bottom accessible.

8. The main contacts shall be capable of being replaced without removing the main power cables.

9. The main contacts shall be visible for inspection without any major disassembly of the transfer switch.

10. When a solid neutral is required, a fully rated bus bar with required AL-CU neutral lugs shall be provided.

11. The complete combination automatic transfer bypass/isolation switch assembly shall be factory tested to ensure proper operation and compliance with the specification requirements. A copy of the factory test report shall be available upon request.

B. Bypass/Isolation Construction

1. All main contacts and operating linkages of the bypass/isolation section shall be identical to the ATS, except that the operation shall be manual.

2. The bypass/isolation switch shall be load break type and shall have the same electrical ratings of ampacity, voltage, short circuit withstand, and temperature rise capability as the associated ATS. The bypass/isolation switch shall be the load-break type. The main contacts of the bypass switch shall be mechanically locked in both the normal bypass and emergency bypass positions without the protected by arcing contacts with magnetic blowouts on each pole. The switching mechanism shall provide "quick-make", "quick-break" operation of the contacts.

3. The primary buss work of the draw-out automatic transfer switch shall be connected to the stationary bus stabs in the freestanding cubicle by silver plated, segmented, self-aligning, primary disconnect fingers to facilitate proper alignment between the removable draw-out when the ATS is withdrawn and shall be available for inspection without disturbing or de-energizing the main bus.

4. The secondary control disconnect contacts mounted on the ATS shall be self-aligning and shall plug into the stationary elements mounted on the freestanding cubicle. Separate, manual, secondary control disconnect plugs are not acceptable.

5. The isolating portion of the bypass/isolation shall allow the automatic transfer switch to be disconnected from all sources of power and control without opening the enclosure door. The transfer switch shall have a true draw-out configuration that does not require disconnection of any electrically or mechanical device by maintaining personnel. The automatic transfer switch shall be provided with rollers or casters to allow it to be removed from its enclosure simply by rolling it out. Positive mechanical interlocks shall be provided to insure that the bypass/isolation functions can be accomplished without the danger of a short circuit. Overlapping contact bypass/isolation switches, that are dependent upon the position of the automatic transfer switch for proper operation, are not acceptable.

6. A fourth pole, switched neutral shall be provided if the associated automatic transfer switch is designed as 4-pole. Basic 4-pole, bypass/isolation switch construction shall be identical to the associated automatic transfer switch construction.

7. Necessary controls shall be provided to ensure that the "engine run" circuit remains closed when the switch is in the bypass-to-emergency position, even though the associated transfer switch is in the "normal" position or completely removed from the enclosure.

C. Automatic Transfer Switch

1. The transfer switch shall be double throw, actuated by two electric operators momentarily energized, and connected to the transfer mechanism by a simple over center type linkage. Minimum transfer time shall be 400 milliseconds.

2. The normal and emergency contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing. Main contacts shall be mechanically locked in both the normal and emergency positions without the use of hooks, latches, magnets, or springs, and shall be silver-tungsten alloy. Separate arcing contacts with magnetic blowouts shall be provided on all transfer switches. Interlocked, molded case circuit breakers or contactors are not acceptable.

3. The transfer switch shall be equipped with a safe external manual operator, designed to prevent injury to operating personnel. The manual operator shall provide the same contact to contact transfer speed as the electrical operator to prevent a flashover from switching the main contacts slowly. The external manual operator shall be safely operated from outside of the transfer switch enclosure while the enclosure door is closed.

D. Automatic Transfer Switch Controls

1. The transfer switch shall be equipped with a microprocessor based control system, to provide all the operational functions of the automatic transfer switch. The controller shall have two asynchronous serial ports. The controller shall have a real time clock with NiCad battery backup.

2. The CPU shall be equipped with self-diagnostics which perform periodic checks of the memory I/O and communication circuits, with a watchdog/power fail circuit

3. The controller shall use industry standard open architecture communication protocol for high speed serial communications via multi-drop connection to other controllers and to a master terminal with up to 4000 ft of cable, or further, with the addition of a communication repeater. The serial communication port shall be RS422/485 compatible.

4. The serial communication port shall allow interface with the manufacturer field service representative and BMS network.

5. The controller shall have password protection required to limit access to qualified and authorized personnel.

6. The controller shall include a 20 character, LCD display, with a keypad, which allows access to the system.

7. The controller shall include three-phase over/under voltage, over/under frequency, phase sequence detection and phase differential monitoring on both normal and emergency sources.

8. The controller shall be capable of storing the following records in memory for access either locally or remotely:

    a. Number of hours transfer switch is in the emergency position (total since record reset).

    b. Number of hours emergency power is available (total since record reset).

    c. Total transfer in either direction (total since record reset).

    d. Date, time, and description of the last four source failures.

    e. Date of the last exercise period.

    f. Date of record reset.

9. The controller shall also be capable of monitoring, logging and trending power data and shall include the following:

    a. The controller shall be accurate to 1% measured. Voltage and current for all phases shall be sampled simultaneously to assure high accuracy in conditions of low power factor or large waveform distortions (harmonics). The controller shall be capable of operating at nominal frequencies of 45 to 66 Hz.

    b. The controller shall accept inputs from industry standard current transformers (5A secondary). Direct phase voltage connections, 600 VAC and under, shall be possible without the use of PT=s.

    c. The controller shall be capable of being applied in single or 3-phase, three and four wire circuits.

    d. The controller shall use industry standard open architecture communication protocol for serial communications via multi-drop connection to other controllers and to a master terminal with up to 4000 feet of cable, or further, with the addition of a communication repeater. The serial communication port shall be RS422/485 compatible.

    e. All setup parameters required by the controller for power monitoring shall be stored in nonvolatile memory and retained in the event of a control power interruption.

    f. The following metered readings shall be communicated by the Controller, via local display and serial communication. And to the master Control Cubicle at the Emergency Generator Control and Distribution Switch Gear:

        1) Current, per phase RMS and neutral

2) Current Unbalance %

3) Voltage, phase-to-phase and phase-to-neutral

4) Voltage Unbalance %

5) Real power (KW), per phase and 3-phase total

6) Apparent power (KVA), per phase and 3-phase total

7) Reactive power (KVAR), per phase and 3-phase total

8) Power factor, 3-phase total & per phase

9) Frequency

10) Accumulated Energy, (KWH, KVAH, and KVARH)

g. Displaying each of the metered quantities shall be accomplished through the use of menu scroll buttons.

h. Setup for systems requirements shall be allowed through the local access display. Setup provisions shall include:

1) CT rating

2) System type (single; three phase, 3 or 4 wire)

i. Reset of the following electrical parameters shall also be allowed from the local access display:

1) Real Energy (KWH)

2) Apparent Energy (KVAH)

3) Reactive Energy (KVARH)

j. All reset and setup functions shall have a means for protection against unauthorized/accidental changes.

k. The Controller shall be capable of storing records in memory for access either locally or remotely for up to 100 events. The reports shall include date, time and a description of the event and shall be maintained in a non-volatile memory.

E. Sequence of Operation

1. When the voltage on any phase of the normal source drops below 80% or voltage differential between phases occurs, after a programmable time delay period of 0-9999 seconds factory set at 3 seconds to allow for momentary dips, the engine starting contacts shall close to start the generating plant.

2. The transfer switch shall transfer to emergency when the generating plant has reached specified voltage and frequency on all phases.

3. After restoration of normal power on all phases to a preset value of at least 90% to 110% of rated voltage, and at least 95% to 105% of rated frequency, and voltage differential is below 20%, an adjustable time delay period of 0-9999 seconds (factory set at 300 seconds) shall delay retransfer to allow stabilization of normal power. If the emergency power source should fail during this time delay period, the switch shall automatically return to the normal source.

4. After re-transfer to normal, the engine generator shall be allowed to operate at no load for a programmable period of 0-9999 seconds, factory set at 300 seconds.

F. Automatic Transfer Switch Accessories

1. Programmable three phase sensing of the normal source set to pick up at 90% and dropout at 80% of rated voltage and overvoltage to pick up at 120% and dropout out at 110% of rated voltage. Programmable frequency pickup at 95% and dropout at 90% and over frequency to pick up at 110% and dropout at 105% of rated frequency. Programmable voltage differential between phases, set at 20%, and phase sequence monitoring.

2. Programmable three phase sensing of the emergency source set to pick up at 90% and dropout at 80% of rated voltage and overvoltage to pick up at 120% and dropout out at 110% of rated voltage programmable frequency pickup at 95% and dropout at 90% and over frequency to pick up at 110% and dropout at 105% of rated frequency. Programmable voltage differential between phases set at 20%, and phase sequence monitoring.

3. Time delay for override of momentary normal source power outages (delays engine start signal and transfer switch operation). Programmable 0-9999 seconds. Factory set at 3 seconds, if not otherwise specified.

4. Time delay to control contact transition time on transfer to either source. Programmable 0-9999 seconds, factory set at 3 seconds.

5. Time delay on retransfer to normal, programmable 0-9999 seconds, factory set at 300 seconds if not otherwise specified, with overrun to provide programmable 0-9999 second time delay, factory set at 300 seconds, unloaded engine operation after re-transfer to normal.

6. Time delay on transfer to emergency, programmable 0-9999 seconds, factory set at 3 seconds.

7. A maintained type load test switch shall be included to simulate a normal power failure.

8. A remote type load test switch shall be included to simulate a normal power failure, remote switch initiated.

9. A time delay bypass on retransfer to normal shall be included. Keypad initiated.

10. Contact, rated 10 Amps 30 volts DC, to close on failure of normal source to initiate engine starting.

11. Contact, rated 10 Amps 30 volts DC, to open on failure of normal source for customer functions.

12. Light emitting diodes shall be mounted on the microprocessor to indicate: switch is in normal position, switch is in emergency position and controller is running.

13. A plant exerciser shall be provided with (10) 7-day events, programmable for any day of the week and (24) calendar events, programmable for any month/day, to automatically exercise generating

14. Provision to select either "no commit" or "commit" to transfer operation in the event of a normal power failure shall be included. In the "no commit position," the load will transfer to the emergency position unless normal power returns before the emergency source has reach 90% of its rated values (switch will remain in normal). In the "commit position" the load will transfer to the emergency position after any normal power failure. Keypad initiated.

15. Four auxiliary contacts rated 10 Amp, 120 volts AC (for switches 100 to 800 amps) 15 amp, 120 volts AC (for switches 1000 to 4000 amps), shall be mounted on the main shaft, two closed on normal, two closed on emergency. All contacts will be wired to a terminal strip for ease of customer connections.

16. A three phase digital LCD voltage readout, with 1% accuracy shall display all three separate phase to phase voltages simultaneously, for both the normal and emergency source.

17. A digital LCD frequency readout with 1% accuracy shall display frequency for both normal and emergency source.

18. An LCD readout shall display normal source and emergency source availability.

19. Include two time delay contacts that open simultaneously just (milliseconds) prior to transfer in either direction. These contacts close after a time delay upon transfer.

Programmable 0-9999 seconds after transfer.

20. A block transfer function shall be included, energized from a 24 VDC signal from the generator control switchgear, to allow transfer to emergency.

21. A load-shed function shall be included, energized from a 24 VDC signal from the generator control switchgear, to disconnect the load from the emergency source when an overload condition occurs.

G. Bypass/Isolation Switch

1. Operation of the bypass/isolation shall be assured, regardless of the position of the automatic transfer switch.

2. Light emitting diodes shall be provided to indicate: bypass position, fully isolated position, and source availability.

3. Positive sequencing of all contacts, with no possible intermediate position, shall be accomplished through the manual operators from a dead front location. Electrical testing during maintenance of the automatic transfer switch shall be possible in the bypass position.

4. Inherent double-throw (break-before-make) operation shall provide positive assurance against accidental short circuitry of the normal and emergency power sources. Arrangements utilizing interlocking of single-throw devices are not acceptable. The operating speed of the contacts shall be independent of the speed at which the handle is moved.

5. The switch shall be fully manually operated and shall not be dependent upon electrical operators, relays, or interlocks for operation.

6. The bypass/isolation switch shall be listed by Underwriters= Laboratories, Inc., Standard UL-1008 and meet the identical withstand ratings of its associated transfer switch.

7. Both the automatic transfer switch and bypass/isolation switch shall be supplied by the same manufacturer. The manufacturer shall verify that the design has been in continuous production for not less than 10 years, with at least 100 similar installations operating continuously and successfully for that period of time.

8. Bypass/isolation switch must have mechanical separation of normal and emergency to assure against accidental connection of unsynchronized sources. Electrical interlocking will not be considered acceptable.

H. Approval

1. As a condition of approval, the manufacturer of the combination automatic transfer

bypass/isolation switches shall verify that their switches are listed by Underwriters Laboratories, Inc., Standard UL-1008 with 3 cycle short circuit closing and withstand higher than available fault and minimum ratings as follows:

RMS Symmetrical Amperes 480 VAC

| Current Limiting Amperes | Closing and Withstand Fuse Rating | |
|---|---|---|
| 100 – 400 | 42,000 | 200,000 |
| 600 – 800 | 65,000 | 200,000 |
| 1000 – 1200 | 85,000 | 200,000 |
| 1600 – 4000 | 100,000 | 200,000 |

2. The AIC ratings of automatic transfer switch shall exceed the available fault current.

3. During the 3 cycle closing and withstand tests, there shall be no contact welding or damage. The 3 cycle tests shall be performed without the use of current limiting fuses. The test shall verify that contact separation has not occurred, and there is contact continuity across all phases. Test procedures shall be in accordance with UL-1008, and testing shall be certified by Underwriters' Laboratories, Inc.

4. When conducting temperature rise tests to UL-1008, the manufacture shall include post-endurance temperature rise tests to verify the ability of the combination transfer bypass/isolation switch to carry full rated current after completing the overload and endurance tests.

5. The microprocessor controller shall meet the following requirements:

   a. Storage conditions - 25 degrees C to 85 degrees C

   b. Operation conditions - 20 degrees C to 70 degrees C ambient

   c. Humidity 0 to 99% relative humidity, non-condensing

   d. Capable of withstanding infinite power interruptions

   e. Surge withstand per ANSI/IEEE C-37.90A-1978

6. Manufacturer shall provide copies of test reports upon request.

## 2.3 SOURCE QUALITY CONTROL

A. Furnish shop inspection and testing of each transfer switch.

B. Make completed transfer switch available for inspection at manufacturer's factory prior to packaging for shipment. Notify LAWA at least seven days before inspection is allowed.

C. Allow witnessing of factory inspections and tests at manufacturer's test facility. Notify LAWA at least seven days before inspections and tests are scheduled.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install 4" concrete housekeeping pads.

B. Install engraved nameplates.

### 3.2 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Perform inspections and tests listed in NETA ATS, Section 7.22.3.

### 3.3 MANUFACTURER'S FIELD SERVICES

A. Check out transfer switch connections and operations and place in service.

### 3.4 ADJUSTING

A. Adjust control and sensing devices to achieve specified sequence of operation.

### 3.5 TRAINING

A. Demonstrate operation of transfer switch in normal and emergency modes to LAWA's staff to be trained.

B. Provide manuals for attendees.

C. Training shall be provided at times for each of 3 shifts.

END OF SECTION

# SECTION 26 32 13
# ENGINE GENERATORS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes engine generator set, exhaust silencer and fittings, fuel fittings and sub base tank, remote control panel, battery, and charger.

B. All generators shall be located outdoors. New underground fuel tanks are not allowed at the airport.

### 1.2 REFERENCES

A. National Electrical Manufacturers Association

1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

2. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.

3. NEMA ICS 10 - Industrial Control and Systems: AC Transfer Switch Equipment.

4. NEMA MG 1 - Motors and Generators.

B. International Electrical Testing Association:

1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

C. National Fire Protection Association:

1. NFPA 30 - Flammable and Combustible Liquids Code.

2. NFPA 110 - Standard for Emergency and Standby Power Systems.

### 1.3 SYSTEM DESCRIPTION

A. Description: Engine generator assembly and accessories to provide source of power for Level 1 and 2 applications in accordance with NFPA 110.

B. Capacity: As required with standby rating using specified engine cooling scheme.

C. Diesel generator muffler, flex and mounting hardware.

D. 8 hour minimum fuel capacity with dual wall sub-base fuel storage tank. Tank shall be

constructed of corrosion resistance steel material.

E. Provide engine generators approved by SCAQMD and local environmental agency for use as emergency backup and Tier 4 regulations compliance.

## 1.4 SUBMITTALS

A. Shop Drawings: Indicate electrical characteristics and connection requirements. Include plan and elevation views with overall and interconnection point dimensions, fuel consumption rate curves at various loads, ventilation and combustion air requirements, electrical diagrams including schematic and interconnection diagrams.

B. Product Data: Submit data showing dimensions, weights, ratings, interconnection points, and internal wiring diagrams for engine, generator, control panel, transfer switch, battery, battery rack, battery charger, exhaust silencer, vibration isolators, day tank, and remote radiator.

C. Test Reports: Indicate results of performance testing.

D. Manufacturer's Field Reports: Indicate inspections, findings, and recommendations.

## 1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Submit instructions and service manuals for normal operation, routine maintenance, oil sampling and analysis for engine wear, and emergency maintenance procedures. Include list of spare parts.

## 1.6 FACTORY PROTOTYPE TESTING

A. The system manufacturer must certify that engine, generator and controls have been tested as a complete system of representative engineering models (not on equipment sold). The manufacturer shall supply equipment that is a current factory standard production model.

B. Prototype testing shall include:

1. Fuel consumption at 1/4, 1/2, 3/4 and full load.

2. Exhaust emissions.

3. Mechanical and exhaust noise.

4. Governor speed regulation at 1/4, 1/2, 3/4 and full load; and during transients

5. Motor starting kVA.

6. Generator temperature rise in accordance with NEMA MG1-22.40 and 16.40

7. Harmonic analysis, voltage waveform deviation and telephone influence factor.

8. Generator short circuit capability.

9. Cooling system performance.

10. 3 phase short circuit tests.

11. Maximum power (kW)

12. Generator revolving field assembly for 2 hours at 2700 rpm (150% overspeed) and 70 degrees C and each production unit tested at 2250 rpm (125% overspeed) at room temperature.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience, and with service facilities within 100 miles of project.

B. Supplier: Authorized distributor of specified manufacturer with minimum ten years documented experience.

1.8 WARRANTY

A. Five Year Manufacturer Warranty: The manufacturer's standard warranty shall in no event be for a period of less than five years form date of initial start-up of the system and shall include repair parts, labor, reasonable travel expense necessary for repairs at the job site, and expendables (lubricating oil, filters, antifreeze, and other service items made unusable by the defect) used during the course of repair. Running hours shall not be a limiting factor for the system warranty by either the manufacturer or servicing distributor. An extended warranty for an additional five years shall be offered as an option. Submittals received without written warranties as specified will be rejected in their entirety.

1.9 MAINTENANCE SERVICE

A. Furnish service and maintenance of engine generators for five years from Date of Substantial Completion.

1.10 MAINTENANCE MATERIALS FOR EACH ENGINE GENERATOR

A. Furnish one set of tools required for preventative maintenance of engine generator system. Package tools in adequately sized metal tool box.

B. Furnish two of each fuel, oil and air filter element.

PART 2 - PRODUCTS

2.1 ENGINE

A. Manufacturers:

1. Caterpillar.

2. Kohler.

3. Cummins.

B. Product Description: Air-cooled in-line or V-type, four-stroke cycle, compression ignition Diesel internal combustion engine.

C. Rating: Standby rating in accordance with ISO-8528 and ISO 3046.

D. Fuel System: No. 2 fuel oil.

E. Engine speed: 1800 rpm.

F. Safety Devices: Engine shutdown on high water temperature, low oil pressure, overspeed, and engine overcrank. Limits as selected by manufacturer.

G. Engine Starting: DC starting system with positive engagement, number and voltage of starter motors in accordance with manufacturer's instructions. Furnish remote starting control circuit, with MANUALOFF-REMOTE selector switch on engine-generator control panel.

H. Engine Jacket Heater: Thermal circulation type water heater with integral thermostatic control, sized to maintain engine jacket water at 90 degrees F, and suitable for operation on 120 or 208 volts AC.

I. Radiator: Radiator using glycol coolant, with blower type fan, sized to maintain safe engine temperature in ambient temperature of 110 degrees F. Radiator air flow restriction 0.5 inches of water maximum.

J. Engine Accessories: Fuel filter, lube oil filter, intake air filter, lube oil cooler, fuel transfer pump, fuel priming pump, gear-driven water pump. Furnish fuel pressure gage, water temperature gage, and lube oil pressure gage on engine/generator control panel.

K. Mounting: Furnish unit with suitable spring-type vibration isolators and mount on structural steel base.

2.2 GENERATOR

A. Manufacturers:

1. As provided by engine generator manufacturer.

B. Product Description: NEMA MG1, three phase, four pole, reconnectable brushless synchronous generator with brushless exciter.

C. Generator voltage, ampere and power factor ratings, as required, to be shown on the drawings.

D. Insulation: The insulation material shall meet NEMA standards for Class H insulation and be vacuum impregnated with epoxy varnish to be fungus resistant. Temperature rise of the rotor and stator shall not exceed NEMA class F. The excitation system shall be of brushless construction.

E. Temperature Rise: 80 degrees C Standby, maximum as measured by resistance and based on 40 degrees C ambient temperature.

F. Enclosure: NEMA MG1, open drip proof

G. Total Harmonic Distortion (THD): Not to exceed three percent.

H. Telephone Influence: Below 50.

I. Exciter (Self-Excited): The self-excited, brushless exciter shall consist of a three-phase armature and a three-phase full wave bridge rectifier mounted on the rotor shaft. Surge suppressors shall be included to protect the diodes from voltage spikes.

J. Automatic Voltage Regulator: The digital automatic voltage regulator (DVR) shall maintain generator output voltage within +/- 0.5% for any constant load between no load and full load. The regulator shall be a totally solid state design, which includes electronic voltage buildup, volts per Hertz regulation, three phase sensing, over excitation protection, loss of sensing protection, temperature compensation, shall limit voltage overshoot on startup, and shall be environmentally sealed.

## 2.3 GOVERNOR

A. Manufacturers:

1. As provided by engine generator manufacturer.

B. Product Description: Isochronous governor to maintain engine speed within 0.5 percent, steady state, and 5 percent, no load to full load, with recovery to steady state within 2 seconds following sudden load changes. Equip governor with means for manual operation and adjustment.

## 2.4 CIRCUIT BREAKER

A. Circuit Breaker Specifications: Provide a generator mounted circuit breaker, molded case or insulated case construction, rating as indicated. Breaker shall utilize a thermal megneic trup unit and 24VDC shunt trip. The breaker shall be UL listed with shunt trip device connected to engine/generator safety shutdowns. Breaker shall be set to protect the generator from short circuit damage. Breaker shall be housed in an extension terminal box mounted on the side of the generator. Mechanical type lugs, sized for the circuit breaker feeders, shall be supplied on the

load side of breaker.

B. Provide an additional circuit breaker for the radiator mounted load bank.

2.5 CONTROL PANEL

A. Generator Mounted Control Panel: Provide a generator mounted control panel for complete control and monitoring of the engine and generator set functions. Panel shall include automatic start/stop operation; adjustable cycle cranking, digital AC metering (0.5% true rms accuracy) with phase selector switch, digital engine monitoring, shutdown sensors and alarms with horn and reset, adjustable cool down timer and emergency stop push-button. Panel shall incorporate self-diagnostics capabilities and fault logging. Critical components shall be environmentally sealed to protect against failure from moisture and dirt. Components shall be housed in a NEMA 1/IP22 enclosure with hinged lid.

B. Digital Readouts: Provide the following digital readouts: These readouts shall be monitored thru building automation and monitoring system in the terminal.

1. Engine oil pressure
2. Coolant temperature
3. Engine RPM
4. System DC Volts
5. Engine running hours
6. Generator AC volts
7. Generator AC amps
8. Generator frequency
9. KW meter
10. Percentage of rated Power
11. KVA meter
12. KVAr meter
13. Power Factor meter
14. KWHR meter

C. Alarm NFPA 110: Provide the following indications for protection and diagnostics according to

NFPA 110 level 1: These items shall be monitored thru building automation and monitoring system in the terminal.

1. Low oil pressure
2. High water temperature
3. Low coolant level
4. Overspeed
5. Over crank
6. Emergency stop depressed
7. Approaching high coolant temperature
8. Approaching low oil pressure
9. Low coolant temperature
10. Low voltage in battery
11. Control switch not in auto position
12. Low fuel main tank
13. Battery charger ac failure
14. High battery voltage
15. EPS supplying load
16. Base mounted tank low fuel level
17. Base mounted tank high fuel level
18. Spare

D. Remote Annunciator NFPA 110: Provide one remote annunciator to meet the requirements of NFPA 110, Level 1. The annunciator will be installed by contractor. The annunciator shall provide remote annunciation of all points stated above and shall incorporate ring-back capability so that after silencing the initial alarm, any subsequent alarms will sound the horn.

E. The location of the remote annunciator shall be clearly identified on the electrical and architectural drawings.

F. Programmable Control Panel: Provide programmable protective relay functions inside the control

panel to include the following:

1. Under voltage
2. Overvoltage
3. Over frequency
4. Under frequency
5. Reverse power
6. Overcurrent (phase and total)
7. KW level (overload)
8. Three spare LED's
9. Four spare inputs

G Engine run time meter. Standalone analog type, non-resettable run-time meter. Units shall be mounted along with the genset control panel.

2.6 FUEL SYSTEM

A. Fuel Filter: Filter/Separator - In addition to the standard fuel filters provided by the engine manufacturer, there shall also be installed a primary fuel filter/water separator in the fuel inlet line to the engine.

B. Fuel Piping: All fuel piping shall be black iron or flexible fuel hose rated for this service. No galvanized piping will be permitted.

C. Fuel Line Rating: Flexible fuel lines rated 300 degrees F and 100 PSI.

D. Sub-Base Fuel Tank.

2.7 SUB-BASE FUEL TANK

A. Manufacturers:

1. IBI
2. International Supply Co.
3. Tramont

B. Provide a sub-base concrete encased fuel tank for the generator set, sized to allow 8 hours of

operation for fire life safety generator and 15 hours of operation for the stand-by power generators.

1. All Protected Base Tanks are UL Secondary Containment list and labeled. It is comprised of a UL142 steel tank, surrounded by a minimum of 6" light weighted insular concrete, enclosed by a UL142 steel outer shell with a interstitial monitoring tube. All steel tanks are tightness tested at the manufacturer's facility, in accordance with testing procedures specified by UL142 for AST's, and meet UL requirements for standard and emergency venting. The interior of the primary tank has been cleaned and free of any loose material, mill scale, or debris. Sub base tanks are UL 2085 listed for the UL 2 hour fire burn test. Tanks must be ballistic and impact rated per UL 2085 specification.

2. The base tank shall be furnished as a complete, factory assembled and tested assembly and listed as an assembly by Underwriters Laboratories, to UL 142 and UL 2085 factory installed.

3. Primary tanks shall be of minimum thickness per UL 142. Inner tanks will be of rectangular configuration per UL standard 142. All welds must comply with AWS, and ASME IX and ASME B31.1.

4. Secondary containment consists of UL 142 primary tank, completely enclosed by a UL 142 secondary containment tank, which is 110% of the primary. Primary and secondary tank will be Rectangular in configuration. Both tanks are pressure tested to between 3PSI and 5PSI per UL requirements. Insulation material will be of a lightweight concrete design. Concrete will be poured in a monolithic method to eliminate voids. The minimum insulation thickness will be 6". The exterior of the tank will be steel.

5. All tank systems and sub-assemblies shall be installed in strict accordance with the manufacturer's recommendations and applicable fire and environmental codes.

6. All tanks are primed with a Rustoleum Shop Coat Enamel. Top coat is an Alkyd High Gloss Enamel paint (Sherwin WilliamsSW6004 Mink.).

7. All tanks to be installed on reinforced engineered concrete slab. Protective barriers shall be installed as required by state and local codes.

8. Tanks shall be marked on a visible side with "Flammable", "Combustible", and "No Smoking", product identification, and other signs as required by state and local codes.

9. The system installation (end user) shall be inspected and approved by the system installer or its certified contractor. The system installer shall submit a comprehensive checklist of quality and safety items associated with the installation of the system and its sub-assemblies to verify that the installation is in compliance with applicable local fire and environmental codes.

C. Features

1. Emergency tank and basin vents.

2. Mechanical level gauge.

3. Fuel supply and return lines, connected to generator set with flexible fuel lines as recommended by the engine manufacturer and in compliance to UL2200 and NFPA requirements.

4. Leak detection provisions, wired to the generator set control for local and remote alarm indication.

5. High and low level float switches to indicate fuel level. Wire switches to generator control for local and remote indication of fuel level.

6. Basin drain.

7. Integral lifting provisions

## 2.8 TIER 4 COMPLIANT CATALYTIC EXHAUST TREATMENT SYSTEM

A. Provide and install as per manufacturer recommendations.

B. Silencer: A critical type silencer, companion flanges, and flexible stainless steel exhaust fitting properly sized shall be furnished and installed according to the manufacturer's recommendation. Mounting shall be provided by the contractor. The silencer shall be mounted so that its weight is not supported by the engine nor will exhaust system growth due to thermal expansion be imposed on the engine. Exhaust pipe size shall be sufficient to ensure that exhaust backpressure does not exceed the maximum limitations specified by the engine manufacturer.

C. Exhaust System with active diesel particulate filter: The muffler and all indoor exhaust piping shall be "lagged" by the contractor to maintain a surface temperature not to exceed 150 degrees F. The insulation shall be installed so that it does not interfere with the functioning of the flexible exhaust fitting. Diesel particulate filter shall be self-cleaning type.

D. Muffler shall be critical type similar to Nelson-300 or equal. Provide engine exhaust roof thimbles with flexible tubes and pipes as required.

E. Diesel Particulate Filter system shall be self-cleaning or regenerative type. Generator shall be provided with necessary load when the generator is on self-cleaning cycle.

## 2.9 STARTING SYSTEM

A. Starting Motor: The engine shall be started by two, 24 V DC electric starting motors. Crank termination switch and 24 V DC fuel solenoid valve shall be provided for remote automatic start/stop capability.

B. Jacket Water Heater: A unit mounted forced circulation type water heater. The heater Watt rating

shall be sized by the manufacturer to maintain jacket water temperature at 90 degrees F, and shall be a 480 volt, three phase, 60 hertz.

C. Batteries: Lead acid batteries of sufficient capacity for four 15 second crank periods with 10 second rest intervals shall be furnished. Battery voltage of 24 V DC shall be derived from four 12 V DC, 205 amp hour high performance batteries, dry charged. Two battery interconnection cables and four battery-to-starter cables.

1. Battery Trays: A battery tray shall be provided for the batteries and shall conform to NEC 480-7(b). It shall be treated to be resistant to deterioration by battery electrolyte. Further, construction shall be such that any spillage or boil-over battery electrolyte shall be contained within the tray to prevent a direct path to ground.

2. Battery Charger: A current limiting battery charger shall be furnished to automatically recharge batteries. Charger shall float at 2.17 volts per cell and equalize at 2.33 volts per cell. It shall include overload protection, silicon diode full wave rectifiers, voltage surge suppressor, DC ammeter, DC voltmeter, and fused AC input. Ac input voltage shall be 120 volts, single phase. Charger shall have LED annunciation for low DC volts, rectifier failure, loss of AC power, high DC volts. Amperage output shall be no less than ten (10) amperes. Charger shall be wall-mounting type in NEMA 1 enclosure.

2.10 RADIATOR MOUNTED LOAD BANK (For 500 KW fire life safety generator)

A. Furnish a continuous duty load bank, complying with UL 508A, mounted directly on the skid base, on the exhaust side of the radiator, complete with all necessary pilot and power control, wiring and devices to furnish a functional system for the intended use. Load bank shall comply with all applicable NEMA, NEC and ANSI Standards. Load bus configuration and load terminations shall be clearly identified.

B. The load bank shall have the capability of maintaining a constraint load for the Emergency Power Supply Source (EPSS), during both exercising and actual use condition. Rating shall be a minimum of 50% of the generator output rating and matched to the EPSS voltage. Load steps at a minimum of three (3) incremental loads, manually controlled.

C. Enclosure shall be suitable for installation on the exhaust side of the engine radiator. It shall match dimensionally the radiator's duct flange height and width without adaptive duct work. The control section shall have a hinged and gasketed access door(s).

D. Manufacturer shall be Avtron load bank K-711 Series, or equal.

E. Construction shall be aluminum or galvanized steel. All fasteners shall be stainless steel. Load elements shall be helically wound and rated to operate at 50% of the maximum continuous wire rating. Each 50 kW element shall have current limiting fuses. (Furnish three (3) sets of three (3) fuses as spares.)

2.11 STAND ALONE MOBILE LOAD BANK (For 2.0 MW stand-by power generators)

A. Furnish a continuous duty load bank, complying with UL 508A, mounted directly on the mobile skid base, complete with all necessary pilot and power control, wiring and devices to furnish a functional system for the intended use. Load bank shall comply with all applicable NEMA, NEC and ANSI Standards. Load bus configuration and load terminations shall be clearly identified.

B. The load bank shall be sized for 2.0 MW of electrical load, with provision for multiple 100kw field selectable load. Load bank shall be provided with the required cam-lock power connection for power and shall have required ports for generator required control interface.

C. Enclosure shall be Nema 4x, color to match generator set. Doors and vent louvers shall be provided with provided with switches to prevent energization of any electric heaters when any doors and air louvers are close.

D. Load bank shall be provided with ventilation fans for operation and for cool down mode.

E. Wheel-lock. Load bank shall be design with required braking system to prevent the unit from moving or rolling while the unit is in use.

2.12 VIBRATION ISOLATORS FOR EACH ENGINE GENERATOR

A. For unit to base provide spring type with neoprene acoustical pads, leveling devices and vertical limit stops. Minimum static deflection shall be 1 inch.

B. For base to concrete pad spring mountings, provide adjustable type to provide minimum clearance of 4 inches between structural base and floor, with alignment and lift off restraints.

C. Provide for engine-generator set base, engine-generator set base and remote radiator and silencer and exhaust pipe.

2.13 SPARE PARTS

A. Deliver 1 set of filter elements (air, fuel and oil), complete set of fuses, for each size used and one belt for every belt drive to LAWA at final acceptance.

2.14 ENCLOSURE

A. Provide a weather proof sound attenuated enclosure.

B. Acoustic mitigation measures may be required due to the generator's proximity to acoustically sensitive areas such as, but not limited to, office areas, conference rooms, etc.

2.15 GENERATOR CABLES.

A. Provide a weatherproof power and control cabling with required connectors at both ends to match point of connection to generator and to connector box.

2.16 SOURCE QUALITY CONTROL

A. Provide shop inspection and testing of completed assembly.

B. Make completed engine-generator assembly available for inspection at manufacturer’s factory prior to packaging for shipment. Notify LAWA at least seven days before inspection is allowed.

C. Allow witnessing of factory inspections and tests at manufacturer’s test facility. Notify LAWA at least seven days before inspections and tests are scheduled.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment in accordance with manufacturer's recommendations, and all applicable codes.

B. Install engraved plastic nameplates.

C. Ground and bond generator and other electrical system components.

3.2 START-UP AND TESTING

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Perform inspections and tests listed in NETA ATS, Section 7.22.

C. Coordinate all start-up and testing activities with LAWA.

D. After installation is complete and normal power is available, the manufacturer's local dealer shall perform the following:

1. Verify that the equipment is installed properly.

2. Check all auxiliary devices for proper operation, including battery charger, jacket water heater(s), generator space heater, remote annunciator, etc.

3. Test all alarms and safety shutdown devices for proper operation and annunciation.

4. Check all fluid levels.

5. Start engine and check for exhaust, oil, fuel leaks, vibrations, etc.

6. Verify proper voltage and phase rotation at the transfer switch before connecting to the load.

7. Perform a 4-hour load bank test at .80 power factor at full nameplate load using a reactive

load bank and cables supplied with the generator. Observe and record the following data at 15-minute intervals:

a. Service meter hours

b. Volts AC - All phases

c. Amps AC - All phases

d. Frequency

e. Power factor or Vars

f. Jacket water temperature

g. Oil Pressure

h. Fuel pressure

i. Ambient temperature

8. Connect the generator to building load and verify that the generator will start and run all designated loads in the building.

E. Contractor to provide full tank prior to order owner acceptance.

3.3 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Perform inspections and tests listed in NETA ATS, Section 7.22.

3.4 MANUFACTURER'S FIELD SERVICES

A. Prepare and start up engine-generator assembly.

3.5 ADJUSTING

A. Adjust generator output voltage and engine speed to meet specified ratings.

3.6 CLEANING

A. Clean engine and generator surfaces. Replace oil and fuel filters with new.

3.7 TRAINING

A. Furnish eight hours of instruction to be conducted at project site with manufacturer's representative to LAWA choice of staff to be trained. Provide training session for each of 3 shifts.

B. Describe loads connected to emergency and standby system and restrictions for future load additions.

C. Simulate power outage by interrupting normal source, and demonstrate system operates to provide emergency and standby power.

D. Provide manuals for attendees.

END OF SECTION

# SECTION 26 33 53
# STATIC UNINTERRUPTIBLE POWER SYSTEM

## PART 1 - GENERAL

### 1.1 SUMMARY

A. This specification defines the electrical and mechanical characteristics and requirements for a continuous-duty three-phase, solid-state, uninterruptible power system (UPS). The UPS shall provide high-quality AC power for sensitive electronic equipment loads.

B. A static UPS is mandatory for all systems that require memory or control retention such as those found in baggage handling and building management systems.

### 1.2 STANDARDS

A. The UPS shall be designed in accordance with the applicable sections of the current revision of the following documents.

1. ANSI C62.41 (IEEE 587)
2. ASME
3. CSA 22.2, No. 107.1
4. FCC Part 15, Class A
5. ISO 9001
6. National Electrical Code (NFPA-70)
7. NEMA PE-1
8. OSHA
9. UL Standard 1778

B. The UPS shall be ETL listed per UL Standard 1778 Uninterruptible Power Supplies.

### 1.3 SYSTEM DESCRIPTION

A. Design Requirements - UPS Module

1. Voltage. Input/output voltage specifications of the UPS shall be:

a. Rectifier Input: As required.

b. Bypass Input (for dual-input modules): As required.

c. Output: Three-phase, 4-wire-plus-ground, as required.

2. Output Load Capacity. Specified output load capacity of the UPS shall be as required at 0.8 lagging power factor.

B. Design Requirements - Matching Battery Cabinet

1. Battery Cells: Sealed, lead-acid, valve-regulated.

2. Reserve Time: 30 minutes at full load, 0.8 power factor, with ambient temperature between 20° and 30°C.

3. Recharge Time: to 95% capacity within ten (10) times discharge time.

C. Modes of Operation

1. The UPS shall be designed to operate as an on-line, double-conversion, reverse- transfer system in the following modes:

a. Normal - The AC equipment is to be continuously powered by the UPS inverter. The rectifier/charger derives power from a utility AC source and supplies DC power to the inverter while simultaneously float- charging a power reserve battery.

b. Emergency - Upon failure of utility AC power, AC equipment is to be powered by the inverter, which without any switching obtains its power from the battery. There shall be no interruption in power to the critical load upon failure or restoration of the utility AC source.

c. Recharge - Upon restoration of utility AC power, after a utility AC power outage, the rectifier/charger shall automatically restart, walk-in, and gradually resume providing power to the inverter and also recharge the battery system.

d. Bypass - If the UPS must be taken out of service for maintenance or repair, or should the inverter overload capacity be exceeded, the static bypass transfer switch shall perform a reverse transfer of the connected equipment from the inverter to the bypass source without interruption in power to the mission critical AC equipment.

D. Performance Requirements

1. AC Input to UPS DD

a. Voltage Configuration for Standard Units: three-phase, 4-wire plus ground.

b. Voltage Range: +10%, -20% of nominal.

c. Frequency: Nominal frequency +/-5%.

d. Power Factor: Up to 0.96 lagging at nominal input voltage and full rated UPS output with input filter.

e. Inrush current: 800% of full load current maximum.

f. Current Limit: 115% of nominal AC input current maximum and 100% of nominal for optional generator operation.

g. Input Current Walk-In: 15 seconds to full rated input current maximum. Field selectable 5 or 20 seconds.

h. Current Distortion: 10% reflected input THD maximum at full load with the optional input filter; 30% reflected input THD maximum at full load without the optional input filter.

i. Surge Protection: The UPS shall be able to sustain input surges without damage per criteria listed in ANSI C62.41 Category A and B.

2. AC Output, UPS Inverter

a. Voltage Configuration: three-phase, 4-wire plus ground

b. Voltage Regulation:

1) +/- 0.5% three-phase RMS average for a balanced three-phase load for the combined variation effects of input voltage, connected load, battery voltage, ambient temperature, and load power factor.

2) +/- 1.0% three-phase RMS average for a 100% unbalanced load for the combined variation effects of input voltage, connected load, battery voltage, ambient temperature, and load power factor.

c. Frequency: Nominal frequency +/-0.1%.

d. Frequency Slew Rate: 5.0 Hertz per second maximum. Field selectable from 0.1 to 5.0 Hz per second.

e. Phase Displacement:

1) +/- 0.5 degree for balanced load,

2) +/- 1.0 degrees for 100% unbalanced load.

f. Bypass Line Sync Range:

1) +/- 0.5 Hertz,

2) Field selectable +/- 0.5 to 5.0 Hz.

g. Voltage Distortion:

1) 1% total harmonic distortion (THD) for linear loads.

2) 2.5% THD for 100% nonlinear loads (3:1 crest factor) without kVA/kW derating.

h. Load Power Factor Range: 1.0 to 0.7 lagging without derating.

i. Output Power Rating: Rated kVA at 0.8 lagging power factor.

j. Overload Capability:

1) 125% for ten minutes (without bypass source).

2) 150% for one minute (without bypass source).

3) 200% for 10 cycles, pulse paralleling with the static switch.

k. Inverter Output Voltage Adjustment: +/-5% manual adjustment.

l. Voltage Transient Response:

1) 100% load step +/- 5.0%.

2) Loss or return of AC input power +/- 1.0%.

3) Manual transfer of 100% load +/- 3.0%.

m. Transient Recovery Time: to within 1% of output voltage within one cycle.

n. Voltage Unbalance: 100% unbalanced load +/- 1%.

o. Fault Clearing: Sub-cycle current of at least 300%.

1.4 ENVIRONMENTAL CONDITIONS

A. The UPS shall be able to withstand the following environmental conditions without damage or degradation of operating characteristics:

1. Operating Ambient Temperature UPS Module: 32°F to 104°F (0°C to 40°C). Battery: 77 +/-9°F (25 +/-5°C).

2. Storage/Transport Ambient Temperature UPS Module: -4°F to 158°F (-20°C to 70°C). Battery: -4°F to 92 (-20F°C to 33°C)

3. Relative Humidity 0 to 95%, non-condensing.

4. Altitude Operating: To 6,600 ft. (2,000 meters) above Mean Sea Level. Derated for higher altitude applications. Storage/Transport: to 40,000 ft. (12,200 meters) above Mean Sea Level.

5. Audible Noise: Noise generated by the UPS under any condition of normal operation shall not exceed 65 dBA measured 1 meter from surface of the UPS.

1.5 SUBMITTALS

A. Proposal Submittals

1. Submittals with the proposal shall include:

a. System configuration with single-line diagrams.

b. Functional relationship of equipment including weights, dimensions, and heat dissipation.

c. Descriptions of equipment to be furnished, including deviations from these specifications.

d. Size and weight of shipping units to be handled by installing contractor.

e. Detailed layouts of customer power and control connections.

f. Detailed installation drawings including all terminal locations.

B. UPS Delivery Submittals

1. Submittals upon UPS delivery shall include a complete set of submittal drawings and one (1) instruction manual that shall include a functional description of the equipment with block diagrams, safety precautions, instructions, step-by-step operating procedures and routine maintenance guidelines, including illustrations.

C. The electrical contractor shall submit ¼”=1’0” scale sketches of all electrical rooms and areas including actual dimensions of all equipment in electrical rooms and indicate clearances per NEC, as well as door swings or other obstacles. Sketches shall be submitted along with or prior to shop drawing submittals. Shop drawing submittal without sketches shall be returned and not reviewed.

1.6 WARRANTY

A. UPS Module

1. The UPS manufacturer shall warrant the UPS module against defects in materials and workmanship for 12 months after the installation is accepted by LAWA.

B. Battery

1. The battery manufacturer's standard warranty shall be passed through to the end user.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications

1. A minimum of twenty years experience in the design, manufacture, and testing of solid-state UPS systems is required. The system shall be designed and manufactured according to world-class quality standards. The manufacturer shall be ISO 9001 certified.

B. Factory Testing

1. Before shipment, the manufacturer shall fully and completely test the system to assure compliance with the specification.

PART 2 - PRODUCT

2.1 FABRICATION

A. Manufacturers:

1. Liebert.

B. Materials

1. All materials of the UPS shall be new, of current manufacture, high grade and free from all defects and shall not have been in prior service except as required during factory testing.

2. The maximum working voltage, current, and di/dt of all solid-state power components and electronic devices shall not exceed 75% of the ratings established by their manufacturer. The operating temperature of solid-state component sub-assembly shall not be greater than 75% of their ratings. Electrolytic capacitors shall be computer grade and be operated at no more than 95% of their voltage rating at the maximum rectifier charging voltage.

C. Wiring

1. Wiring practices, materials and coding shall be in accordance with the requirements of the National Electrical Code (NFPA 70). All bolted connections of bus bars, lugs, and cables shall be in accordance with requirements of the National Electrical Code and other applicable standards. All electrical power connections are to be torqued to the required value and marked with a visual indicator.

2. Provision shall be made for power cables to enter or leave from the top or bottom of the UPS cabinet.

D. Construction and Mounting

1. The UPS unit, comprised of input transformer (if required), rectifier/charger with input filter, inverter, static transfer switch, output transformer and maintenance bypass switch, shall be housed in a single free-standing NEMA type 1 enclosure. Cabinet doors/covers shall require a tool for gaining access. Casters and stops shall be provided for ease of installation. Front access only shall be required for expedient servicing, adjustments, and installation. The UPS cabinet shall be structurally adequate and have provisions for hoisting, jacking, and forklift handling.

2. The UPS cabinet shall be cleaned, primed, and painted with the manufacturer's standard color. The UPS shall be constructed of replaceable subassemblies. Printed circuit assemblies shall be plug connections. Like assemblies and like components shall be interchangeable.

E. Cooling

1. Cooling of the UPS shall be by forced air. Low-velocity fans shall be used to minimize audible noise output. Fan power shall be provided by the UPS output.

2. The thermal design, along with all thermal and ambient sensors, shall be coordinated with the protective devices before excessive component or internal cabinet temperatures are exceeded.

F. Grounding

1. The AC output neutral shall be electrically isolated from the UPS chassis. The UPS chassis shall have an equipment ground terminal. Provisions for local bonding shall be provided.

2.2 COMPONENTS

A. Input Transformer

1. When required, the input transformer shall be factory installed inside the UPS module cabinet without increasing the standard footprint.

B. Rectifier/Charger

1. General

a. The term rectifier/charger shall denote the solid-state equipment and controls necessary to convert incoming AC power to regulated DC power for input to the inverter and for battery charging. The rectifier/charger shall be a phase-controlled, solid-state SCR type with constant voltage/current limiting control

circuitry.

2. AC Input Current Limiting

   a. The rectifier/charger unit shall be provided with AC input current limiting whereby the maximum input current shall be limited to 115% of the full input current rating. The rectifier/charger shall operate at a reduced current limit mode whenever the critical load is powered from the UPS static bypass circuit such that the maximum UPS input current will not exceed 115% of full load input current. In addition, the rectifier/charger shall have a separate battery current limit, adjustable from 0 to 15% of the full load input current. An optional second circuit shall limit the battery recharge current to zero when activated by a customer-supplied contact closure to signal a customer function such as generator operation.

3. Input Current Walk-In

   a. The rectifier/charger shall contain a timed walk-in circuit that causes the unit to gradually assume the load over a 15-second time interval after input voltage is applied. Walk-in time shall be field selectable for 5 or 20 seconds.

4. Fuse Failure Protection

   a. Power semiconductors in the rectifier/charger shall be fused with fast- acting fuses, so that loss of any one-power semiconductor shall not cause cascading failures.

5. DC Filter

   a. The rectifier/charger shall have an output filter to minimize ripple voltage into the battery. Under no conditions shall ripple voltage into the battery exceed 1% RMS. The filter shall be adequate to insure that the DC output of the rectifier/charger will meet the input requirements of the inverter. The inverter shall be able to operate from the rectifier/charger with the battery disconnected.

6. Automatic Rectifier Restart

   a. Upon restoration of utility AC power, after a utility AC power outage and prior to a UPS automatic end-of-discharge shutdown, the rectifier/charger shall automatically restart, walk-in, and gradually resume providing power to the inverter and also recharge the battery system.

7. Battery Recharge

   a. In addition to supplying power for the inverter load, the rectifier/charger shall be capable of producing battery charging current sufficient to replace 95% of the battery discharge power within ten (10) times the discharge time. After the battery is recharged, the rectifier/charger shall maintain the battery at full charge

until the next emergency operation.

8. DC Over Voltage Protection

a. There shall be DC over-voltage protection so that if the DC voltage rises to the pre-set limit, the UPS is to shut down automatically and initiate an uninterrupted transfer of the connected equipment to the static bypass line.

C. Inverter

1. General

a. The term inverter shall denote the solid-state equipment and controls to convert DC power from the rectifier/charger or battery to regulated AC power for supporting the critical load. The inverter shall use Insulated Gate Bipolar Transistors (IGBTs) in a phase-controlled, pulse width modulated (PWM) design capable of providing the specified AC output.

2. Overload Capability

a. The inverter shall be capable of supplying current and voltage for overloads exceeding 100% and up to 200% of full load current. A status indicator and audible alarm shall indicate overload operation. The UPS shall transfer the load to bypass when overload capacity is exceeded.

3. Fault Clearing and Current Limit

a. The inverter shall be capable of supplying an overload current of 150% of its full-load rating for one minute. For greater currents or longer time duration, the inverter shall have electronic current-limiting protection to prevent damage to components. The critical load will be transferred to the static bypass automatically and uninterrupted. The inverter shall be self-protecting against any magnitude of connected output overload. Inverter control logic shall sense and disconnect the inverter from the critical AC load without the requirement to clear protective fuses.

4. Step Load Response

a. The output voltage shall be maintained to within □-to-5.0% with a 0 100% step load change or a 100%-to-0 step load change. The output voltage shall recover to within 1% of nominal voltage within 1 cycle.

5. Voltage Distortion

a. For linear loads, the output voltage total harmonic distortion (THD) shall not be greater than 1%. For 100% rated load of 3:1 crest factor nonlinear loads, the output voltage total harmonic distortion shall not be greater than 2.5%. The output rating is not to be derated in kVA or kW due to the 100% nonlinear load

with 3:1 crest factor.

6. Output Power Transformer

   a. A dry-type power transformer shall be provided for the inverter AC output. It shall have copper wiring exclusively. The transformers hottest spot winding temperature shall not exceed the temperature limit of the transformer insulation class of material when operating at full load at maximum ambient temperature.

7. Phase Balance

   a. Electronic controls shall be provided to regulate each phase so that an unbalanced loading will not cause the output voltage to go outside the specified voltage unbalance or phase displacement. With 100% load on one phase and 0% load on the other 2 phases or 100% load on 2 phases and 0% load on the other phase, the voltage balance is to be within 1% and the phase displacement is to be 120 degrees within 1 degree.

8. Fuse Failure Protection

   a. Power semiconductors in the inverter shall be fused with fast-acting fuses, so that loss of any one-power semiconductor will not cause cascading failures.

9. Inverter Shutdown

   a. For rapid removal of the inverter from the critical load, the inverter control electronics shall instantaneously turn off the inverter transistors. Simultaneously, the static transfer switch shall be turned on to maintain continuous power to the critical load.

10. Inverter DC Protection

    a. The inverter shall be protected by the following disconnect levels:

       1) DC Over voltage Shutdown

       2) DC Under voltage Warning (Low Battery Reserve), user adjustable from 1 to 99 minutes

       3) DC Under voltage Shutdown (End of Discharge)

11. Over Discharge Protection

    a. To prevent battery damage from over discharging, the UPS control logic shall automatically raise the shutdown voltage set point as discharge time increases beyond fifteen (15) minutes.

12. Inverter Output Voltage Adjustment

a. The inverter shall use a software control to adjust the output voltage from +/- 5% of the nominal value.

13. Output Frequency

a. An oscillator shall control the output frequency of the inverter. The oscillator shall be temperature compensated and hold the inverter output frequency to +/- 0.1% for steady state and transient conditions. Frequency drift shall not exceed 0.1% during a 24-hour period. Total frequency deviation, including short time fluctuations and drift, shall not exceed 0.1% from the rated frequency.

D. Display and Controls

1. Monitoring and Control

a. The UPS shall be provided with a microprocessor based unit status display and controls section designed for convenient and reliable user operation. A graphical display shall be used to show a single-line diagram of the UPS, and shall be provided as part of the monitoring and controls sections of the UPS. All of the operator controls and monitors shall be located on the front of the UPS cabinet. The monitoring functions such as metering, status and alarms shall be displayed on the graphical LCD display. Additional features of the monitoring system shall include:

1) Menu-driven display with pushbutton navigation

2) Real time clock (time and date)

3) Alarm history with time and date stamp

4) Battery backed-up memory

2. Metering

a. The following parameters shall be displayed:

1) Input AC voltage line-to-line

2) Input AC current for each phase

3) Input frequency

4) Battery voltage

5) Battery charge/discharge current

6) Output AC voltage line-to-line and line-to-neutral for each phase

7) Output AC current for each phase

8) Output frequency

9) Percent of rated load being supplied by the UPS

10) Battery time left during battery operation

3. Alarm Messages

a. The following alarm messages shall be displayed:

1) Input Line Fault

2) Input Phase Rotation Error

3) Input Over/Under Frequency

4) Input Current Limit

5) Rectifier Fail

6) Battery Test Failed

7) Battery Low Warning (Adjustable 1 To 99 Minutes)

8) Battery Low Transfer

9) DC Over Voltage Steady State

10) Bypass Frequency Error

11) Load On Bypass

12) Excessive Auto Retransfers

13) SBS SCR Shorted

14) Bypass Sync Error

15) Input Phase Loss

16) I DC Peak

17) Output Under Voltage Transfer

18) Output Over Voltage Transfer

19) Inverter Overload

20) SBS Overload

21) Inverter Overload Transfer

22) Transfer Failed Shutdown

23) Hardware Shutdown

24) Output Power Supply Fail

25) Inverter Control Fault Transfer

26) EPO Latched (remote EPO activated)

27) System Fan Fail

28) Ambient Over Temperature Limit

29) Over Temperature Timeout Shutdown

b. An audible alarm shall be provided and activated by any of the above alarm conditions.

4. Status Messages

a. The following UPS status messages shall be displayed:

1) Normal operation

2) On SBS

3) Load on UPS

4) Load on bypass

5) User Shutdown

6) Battery Discharging

5. Controls

a. UPS start-up, shutdown, and bypass operations shall be accomplished through the front-panel pushbutton controls. Menu-driven user prompts shall be provided to guide the operator through system operation without the use of additional manuals. Pushbuttons shall be provided to display the status of the UPS and to test and reset visual and audible alarms. A mimic diagram screen shall be

available on the LCD screen to depict a single-line diagram of the UPS and indicate switch positions and power flow.

6. On-Line Battery Test

a. The UPS shall be provided with a menu-driven On-Line Battery Test feature. The test shall ensure the capability of the battery to supply power to the inverter while the load is supplied power in the normal mode. If the battery fails the test, the system shall automatically do the following:

1) Maintain the load through the UPS

2) Display a warning message

3) Sound an audible alarm

b. The battery test feature shall have the following user selectable options:

1) Interval between tests (2 to 9 weeks)

2) Date and time of initial test

3) Enable/disable test

E. Static Transfer Switch

1. General

a. A static transfer switch and bypass circuit shall be provided as an integral part of the UPS. The static switch shall be a naturally commutated high- speed static (SCR-type) device rated to conduct full load current continuously. The switch shall have an overload rating of 110% rated load continuously, 200% rated load for five seconds. The static transfer switch shall also have fault-clearing capabilities of 1100 amperes for 1 second, 3000 amperes for 10 cycles, and 6000 amperes peak for the first half cycle.

b. The static transfer switch control logic shall contain an automatic transfer control circuit that senses the status of the inverter logic signals, and operating and alarm conditions. This control circuit shall provide an uninterrupted transfer of the load to an alternate bypass source, without exceeding the transient limits specified herein, when an overload or malfunction occurs within the UPS, or for bypassing the UPS for maintenance.

2. Uninterrupted Transfer

a. The transfer control logic shall automatically turn on the static transfer switch, transferring the critical AC load to the bypass source, after the transfer logic senses any of the following conditions:

1) Inverter overload capacity exceeded

2) AC output over voltage or under voltage

3) Battery protection period expired

4) UPS fault condition

b. The transfer control logic shall inhibit an automatic transfer of the critical load to the bypass source if any of the following conditions are present:

1) Inverter/bypass voltage difference exceeding preset limits

2) Bypass frequency out of limits

3) Bypass out-of-synchronization range with inverter output

3. Uninterrupted Retransfer

a. Re-transfer of the mission critical AC equipment from the bypass source to the inverter output shall be automatically initiated unless inhibited by manual control. The transfer control logic shall inhibit an automatic retransfer of the critical load to the inverter if one of the following conditions exists:

(1) Bypass out of synchronization range with inverter output

(2) Inverter/bypass voltage difference exceeding preset limits

(3) Overload condition exists in excess of inverter full load rating

(4) UPS fault condition present

F. Internal Maintenance Bypass Switch

1. General

a. A manually operated maintenance bypass switch shall be incorporated into the UPS cabinet to directly connect the critical load to the bypass AC input power source, bypassing the rectifier/charger, inverter, and static bypass transfer switch.

2. Isolation

a. All energized terminals shall be shielded to ensure that maintenance personnel do not inadvertently come in contact with energized parts or terminals. A means to de-energize the static bypass switch shall be provided when the UPS is in the maintenance bypass mode of operation.

3. Maintenance Capability

a. With the critical load powered from the maintenance bypass circuit, it shall be possible to check out the operation of the rectifier/charger, inverter, battery, and static bypass transfer switch.

4. Battery Cabinet System

a. The matching battery cabinet shall include sealed, lead-acid valve regulated battery cells housed in a separate cabinet that matches the UPS cabinet styling to form an integral system line-up. Battery cells shall be mounted on slide-out trays for ease of maintenance. A battery disconnect circuit breaker with under voltage release (UVR) shall be included for isolation of the battery system from the UPS module. The UPS shall automatically be disconnected from the battery by opening the breaker when the battery reaches the minimum discharge voltage level. Casters and leveling feet shall also be provided with the battery cabinet for ease of installation. When the application calls for the battery cabinet to be bolted to the UPS cabinet, the interconnecting cables are to be provided, precut to the correct length and cable lugs installed, by the UPS manufacturer.

G. Accessories

1. Input Filter

a. Specific accessories will be dependent on design.

b. The rectifier/charger shall include an input filter to reduce reflected input current distortion to 10% THD at full load with nominal input voltage. Another benefit of the input filter shall be to maintain the input power factor at 0.90-0.96 lagging minimum from full load to half load with nominal input voltage.

2. External Maintenance Bypass Cabinet

a. A matching external maintenance bypass cabinet shall be provided to enable the UPS module to be completely isolated from the electrical system while the critical load is powered through the external maintenance bypass line. This optional cabinet shall provide make- before-break operation for transfers to and from the external maintenance bypass line with a single rotary switch. The following components shall be standard: single rotary switch with auxiliary contacts, inter-cabinet wiring, casters, and leveling feet. The following components shall be optional: input circuit breaker, shielded isolation transformer, and output circuit breaker. This matching cabinet shall bolt to the side of the UPS module with a barrier shield to separate the two cabinets. Only front access shall be required for installation and service.

3. Slim-Line Distribution Cabinet

a. A matching distribution cabinet shall be provided for flexible cable distribution of power from the UPS output to the critical loads. The distribution cabinet shall include one or two 42-pole panel boards. Both plug-in and bolt-in style panel boards shall be available to accommodate specific site requirements. A main circuit breaker shall be provided with each panel board.

b. The Slim-Line distribution cabinet shall be designed as a bolt-on section to the UPS module or Maintenance Bypass cabinet for field installation by the installing contractor. The Slim-Line distribution cabinet shall add no more than ten (10) inches to the width of the UPS system.

4. 1+1 Redundant Paralleling

a. The UPS shall be available in a version capable of parallel-redundant operation. Two modules with the paralleling option board shall be connected to a simple parallel cabinet requiring no system-level controls or displays. The parallel cabinet shall include two module isolation circuit breakers and one system output breaker. All control and load- sharing logic shall be independent and contained within each module. The only control connection between the two modules shall be a single Category 5 Ethernet cable. The UPS modules shall load share within 1% when the Ethernet cable is attached. As a fail-safe operating mode, the UPS modules shall be capable of load sharing within 5% even if the Ethernet cable is removed or damaged after system start-up. In like manner, the system shall be capable of operating normally (including overload and fault handling, manual transfers and automatic transfers to bypass) for an indefinite period with no inter-module signals available.

5. Load Bus Synchronization

a. The Load Bus Sync® circuit shall synchronize the output of two independent UPSs even if the UPSs are operating from asynchronous bypass sources (e.g. backup generator sets) or on battery power. The Load Bus Sync (LBS) circuit shall consist of a control enclosure and an option card inside each UPS module. The LBS control enclosure shall enable the operator to designate which bypass source will be the Designated Master source, and both UPS systems will synchronize their outputs to that source.

6. Programmable Relay Board

a. Eight sets of isolated Form C contacts shall be provided to indicate a change of status of any of the alarm conditions. Any of the UPS alarms can be programmed onto any channel of the programmable relay board.

7. Remote Status Panel

a. A remote status panel shall be provided and shall include the following:

1) Load on UPS LED

2) Load On Bypass LED

3) Battery Discharge LED

4) Low Battery Reserve LED

5) UPS Alarm Condition LED

6) New Alarm Condition LED (for a second UPS alarm condition)

7) Audible Alarm with Reset pushbutton

8) Lamp Test/Reset pushbutton

b. The remote status panel shall be provided in a NEMA Type 1 enclosure for wall mounting.

8. Battery Circuit Breaker

a. A battery circuit breaker shall be provided to isolate the battery from the UPS. This breaker shall have an under voltage release (UVR) and auxiliary contacts, and shall be in a separate wall mounted NEMA-1 enclosure. The battery breaker provides a manual disconnecting means, short circuit protection, and over current protection for the battery system. When opened, there shall be no battery voltage in the UPS enclosure. The UPS shall be automatically disconnected from the battery by opening the breaker when the battery reaches the minimum discharge voltage level.

9. Internal Modem

a. The UPS shall come with an internal modem capable of dialing out from the UPS to notify up to two remote computers, terminals, PC's, or pocket pagers when important events occur. The modem will also be capable of accepting incoming calls, with the appropriate security, and connecting to a remote terminal, computer or PC, to perform all those functions normally available on the front panel including viewing monitoring screens.

10. SNMP

a. The UPS shall come equipped with an internal SNMP adapter, which will connect the UPS directly to any I.P. based network using Ethernet communications. The UPS will become a managed device on the network. From a network management station the system administrator shall be capable of monitoring important system measurements, alarm status and alarm history data. In the event of a utility failure the SNMP shall continue with live communication without the requirement of additional or separate UPS equipment until such time as the UPS shuts down for Low battery. On resumption of Utility power the SNMP shall resume full SNMP communication

automatically.

11. IBM* AS/400* UPS Signal

    a. The following isolated normally open contacts shall be provided for user connection to an IBM AS/400 UPS signal interface:

        1) UPS on (UPS is supplying power)

        2) Bypass active (bypass is supplying power)

        3) Utility failure (battery is discharging)

        4) Battery low (limited battery time remaining)

    b. A 50-foot shielded cable, compliant with NEMA Class 2 for plenum applications, with sub-miniature 9-pin D-type connector, shall be provided for connection to the signal interface.

12. IBM* AS/400* Multi-Interface System

    a. An AS/400 Multi-Interface System shall be provided where a single UPS is powering multiple AS/400 units (up to 8). The MultiInterface Unit (MIU) shall provide the required UPS status information to each AS/400 so it can perform an automatic unattended orderly shutdown when necessary. Each AS/400 includes the software required to interface with the UPS. The following status messages are activated in the IBM system:

        1) UPS on (UPS is supplying power)

        2) Bypass active (bypass is supplying power)

        3) Utility failure (battery is discharging)

        4) Battery low (limited battery time remaining)

    b. Each AS/400 individually monitors the UPS status to determine when to initiate a quick power down to preserve data and protect hardware during a utility power outage. This system requires the optional remote contact board to provide isolated contacts. This system shall include a shielded primary cable with a 9-pin subminiature D-shell connector, the AS/400 Multi-Interface Unit (MIU), and shielded secondary cables with RJ11 and 9-pin subminiature D-shell connectors. Cables shall be available in selected lengths from 25 to 300 feet.

    c. IBM and AS/400 are trademarks of International Business Machines Corporation.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Factory-trained field service personnel shall perform the following inspections and test procedures during the UPS startup.

1. Visual Inspection

a. Inspect equipment for signs of damage

b. Verify installation is correct

c. Inspect cabinets for foreign objects

d. Verify neutral and ground conductors are properly sized and configured

e. Inspect battery cases

f. Inspect battery for proper polarity

g. Verify all printed circuit boards are configured properly

2. Mechanical Inspection

a. Check all control wiring connections for tightness

b. Check all power wiring connections for tightness

c. Check all terminal screws, nuts, and/or spade lugs for tightness

3. Electrical Inspection

a. Check all fuses for continuity

b. Confirm input voltage and phase rotation is correct

c. Verify control transformer connections are correct for voltages being used

d. Assure connection and voltage of the battery string(s)

3.2 MANUFACTURER'S FIELD SERVICE

A. Service Personnel

1. The UPS manufacturer shall directly employ a nationwide service organization, consisting of factory trained field service personnel dedicated to the start-up,

maintenance, and repair of UPS and power equipment. The organization shall consist of regional and local offices.

2. The manufacturer shall provide a fully automated national dispatch center to coordinate field service personnel schedules. One toll-free number shall reach a qualified support person 24 hours/day, 7 days/week, and 365 days/year. If emergency service is required, response time shall be 20 minutes or less.

3. An automated procedure shall be in place to insure that the manufacturer is dedicating the appropriate technical support resources to match escalating customer needs.

B. Replacement Parts Stocking

1. Parts shall be available through an extensive network to ensure around-the-clock parts availability throughout the country.

2. Recommended spare parts shall be fully stocked by local field service personnel with back-up available from national parts center and the manufacturing location. The national parts center Customer Support Parts Coordinators shall be on-call 24 hours/day, 7 days/week, and 365 days/year for immediate parts availability. Parts from the national parts center shall be shipped within 4 hours on the next available flight out and delivered to the customer's site within 24 hours.

C. UPS Operator Training

1. Operator training courses for customer employees shall be available by the UPS manufacturer. The training course shall cover UPS theory, safety, battery considerations and UPS operational procedures.

2. Training and materials shall be provided for LAWA personnel.

D. Maintenance Contracts

1. A complete offering of preventive and full service maintenance contracts for both the UPS system and battery system shall be available. An extended warranty and preventive maintenance package shall be available. Factory-trained service personnel shall perform warranty and preventive maintenance service.

END OF SECTION

# SECTION 26 43 13
# TRANSIENT-VOLTAGE SUPPRESSION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. This Section includes transient voltage surge suppressors for low-voltage power, control, and communication equipment.

### 1.2 DEFINITIONS

A. ATS: Acceptance Testing Specifications.

B. SVR: Suppressed voltage rating.

C. TVSS: Transient voltage surge suppressor(s), both singular and plural; also, transient voltage surge suppression.

### 1.3 SUBMITTALS

A. Product Data: For each type of product. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

B. Product Certificates: For TVSS devices, from manufacturer.

C. Field Test Reports: Written reports of tests specified in Part 3 of this Section.

### 1.4 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors which fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

B. 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.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Manufacturers of a Broad Line of Suppressors:

1. Cutler-Hammer, Inc.

2. Square D Co.

3. General Electric.

C. Manufacturers of Category A and Telephone/Data Line Suppressors:

1. MCG Electronics, Inc.

2. NTE Electronics, Inc.

3. Telebyte Technology, Inc.

2.2 SERVICE ENTRANCE SUPPRESSORS

A. Surge Protective Device Description: Non-modular type with the following features and accessories:

1. LED indicator lights for power and protection status.

2. Copper lugs.

3. Audible alarm, with silencing switch, to indicate when protection has failed.

4. One set of dry contacts rated at 5 amps, 250-Vac, for remote monitoring of protection status.

B. Surge Protective Device Description: Modular design with field-replaceable modules and the following features and accessories:

1. Fuses, rated at 200-kA interrupting capacity.

2. Fabrication using bolted compression lugs for internal wiring Copper lugs.

3. Integral disconnect switch.

4. Arrangement with copper busbars and for bolted connections to phase buses, neutral bus, and ground bus.

5. Arrangement with wire connections to phase buses, neutral bus, and ground bus.

6. Red and green LED indicator lights for power and protection status.

7. Audible alarm, with silencing switch, to indicate when protection has failed.

8. One set of dry contacts rated at 5 amps and 250-Vac, for remote monitoring of protection status.

9. Surge-event operations counter.

10. Peak Single-Impulse Surge Current Rating: 240kA per phase.

11. Connection Means: Permanently wired.

C. Protection modes and UL 1449 clamping voltage for grounded wye circuits with voltages of 480Y/277 and 208Y/120; 3-phase, 4-wire circuits, shall be as follows:

1. Line to Neutral: 800 V for 480Y/277 and 400 V for 208Y/120 .

2. Line to Ground: 800 V for 480Y/277 and 400 V for 208Y/120.

3. Neutral to Ground: 800 V for 480Y/277 and 400 V for 208Y/120.

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

1. Line to Neutral: 400 V.

2. Line to Ground: 400 V.

3. Neutral to Ground: 400 V.

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

1. Line to Neutral: 400 V, 800 V from high leg.

2. Line to Ground: 400 V.

3. Neutral to Ground: 400 V.

F. Protection modes and UL 1449 clamping voltage for voltages of 240, 480, 3-phase, 3-wire, delta circuits shall be as follows:

1. Line to Line: 2000 V for 480 V and 1000 V for 240 V.

2. Line to Ground: 2000 V for 480 V and 1000 V for 240 V.

2.3 PROJECT CONDITIONS

A. Service Conditions: Rate TVSS devices for continuous operation under the following conditions unless otherwise indicated:

1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.

2. Operating Temperature: 30 to 120 deg F.

3. Humidity: 0 to 85 percent noncondensing.

4. Altitude: Less than 20,000 feet above sea level.

2.4 PANELBOARD SUPPRESSORS

A. Surge Protective Device Description: Non-modular type with the following features and accessories:

1. LED indicator lights for power and protection status Copper lugs.

2. Audible alarm, with silencing switch, to indicate when protection has failed.

3. One set of dry contacts rated at 5 amps, 250-Vac, for remote monitoring of protection status.

4. Fuses, rated at 200-kA interrupting capacity.

5. Fabrication using bolted compression lugs for internal wiring.

6. Integral disconnect switch.

7. Arrangement with wire connections to phase buses, neutral bus, and ground bus.

8. Red and green LED indicator lights for power and protection status.

9. Audible alarm, with silencing switch, to indicate when protection has failed.

10. One set of dry contacts rated at 5 amps, 250-Vac, for remote monitoring of protection status.

11. Surge-event operations counter.

B. Peak Single-Impulse Surge Current Rating 120 kA per phase.

C. Protection modes and UL 1449 clamping voltage for grounded wye circuits with voltages of 480Y/277 and 208^/120; 3-phase, 4-wire circuits, shall be as follows:

1. Line to Neutral: 800 V for 480Y/277 and 400 V for 208/120.

2. Line to Ground: 800 V for 480Y/277 and400 V for 208Y/120.

3. Neutral to Ground: 800 V for 480Y/277 and400 V for 208Y/120.

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

1. Line to Neutral: 400 V.

2. Line to Ground: 400 V.

3. Neutral to Ground: 400 V.

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

1. Line to Neutral: 400 V, 800 V from high leg.

2. Line to Ground: 400 V.

3. Neutral to Ground: 400 V.

F. Protection modes and UL 1449 clamping voltage for voltages of 240, 480, 3-phase, 3-wire, delta circuits shall be as follows:

1. Line to Line: 2000 V for 480 V and1000 V for 240 V.

2. Line to Ground: 1500 V for 480 V and800 V for 240 V.

## 2.5 ENCLOSURE

A. NEMA 250, with type matching the enclosure of panel or device being protected.

# PART 3 - EXECUTION

## 3.1 INSTALLATION OF SURGE PROTECTIVE DEVICES

A. Install devices at service entrance on load side, with ground lead bonded to service entrance ground.

B. Install devices for panelboard with conductors 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.

C. Provide multipole, 15-A circuit breaker as a dedicated disconnect for the suppressor, unless otherwise indicated, or direct bus mounted, internal to electrical equipment.

## 3.2 CONNECTIONS

A. 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.

## 3.3 TRAINING

A. Engage a factory-authorized service representative to train LAWA maintenance personnel to adjust, operate, and maintain surge protective devices.

B. Train LAWA maintenance personnel on procedures and schedules for maintaining suppressors.

C. Review data in maintenance manuals.

D. Schedule training with LAWA with at least seven days' advance notice.

END OF SECTION

# SECTION 26 51 00
# INTERIOR LIGHTING

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes interior luminaires, lamps, ballasts and accessories.

B. Consider the use of pendant lighting that may make the fixture more accessible for routine maintenance. Linear lighting is preferred over typical "can" down lights.

C. Related Sections: Division 26 Series.

### 1.2 REFERENCES

A. American National Standards Institute:

1. ANSI C82.1 - American National Standard for Lamp Ballast-Line Frequency Fluorescent Lamp Ballast.

B. ANSI C82.4 - American National Standard for Ballasts-for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type).

C. Illuminating Engineering Society of North America

D. UL Underwriters Laboratories

E. ETL Intertek Testing Services

F. NEC National Electric Code

G. NEMA National Electrical Manufacturers Association

H. CBM Certified Ballast Manufacturers

### 1.3 DEFINITIONS

A. BF: Ballast Factor

B. CCT: Correlated Color Temperature

C. HID: High Intensity Discharge

D. LED: Light Emitting Diode

E. LER: Luminaire Efficiency Rating

F. Lumen: Measured output of luminaire, lamp, or both.

G. Luminaire: Complete lighting fixture, including driver or ballast, if included.

1.4 SUBMITTALS

A. Shop Drawings: Indicate dimensions and components for each luminaire not standard product of manufacturer.

B. Product Data: Submit dimensions, ratings, and performance data.

C. Samples: Submit two color chips 3 x 3 inch in size illustrating luminaire finish color where indicated in luminaire schedule.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum two years documented experience.

B. Photometric Data: For qualified agencies providing photometric data for lighting fixtures.

1.6 QUALITY ASSURANCE

A. Provide Luminaire Data Photometric Testing performed by an independent agency complying with IESNA Lighting Measurement Testing and Calculation Guides.

B. Comply with NFPA 70.

1.7 MOCK-UP

A. Quality Requirements: Mock-up requirements.

1.8 FIELD MEASUREMENTS

A. Verify all critical measurements in the field prior to fabrication.

1.9 COORDINATION

A. Coordinate layout and installation of light fixtures with other construction.

1.10 MAINTENANCE MATERIALS

A. Execution and Closeout Requirements: Spare parts and maintenance products.

1.11 WARRANTIES

A. All fixtures and workmanship shall be guaranteed free of defects and fully operational for the duration of the warranty period. Defective fixtures or workmanship will be replaced by the Contractor at no cost to the Owner.

B. Ballasts for fluorescent fixtures, transformers for low voltage fixtures, and drivers for LED fixtures shall be warranted against defects in workmanship or material. Warranty to provide for replacement of fluorescent ballasts, transformers for low voltage fixtures, and LED drivers at no cost to the Owner.

PART 2 - PRODUCTS

2.1 INTERIOR LUMINAIRES

A. Highly efficient LED fixtures with consistent color temperature (tight binning), high Color Rendering Index (85+ CRI), and rated life greater than 50,000 hours are preferred.

B. Product Description: Complete interior luminaire assemblies, with features, options, and accessories as scheduled.

2.2 LED LIGHTING FIXTURES AND COMPONENTS

A. Manufacturers:

1. Lighting Science Group.

2. Con-Tech Lighting.

3. Bega Lighting.

4. Lunera Lighting.

B. Product Testing: Comply with U.L. 1598 and 8750. Test according to IES LM-79 and LM-80.

C. Drivers: Operation to be at standard rated voltage of driver, and not “over-driven.”

D. T5 and compact fluorescent lamps/ballasts are recommended for use on the project. Minimize the lamp types for stocking and purchasing purposes.

2.3 FLUORESCENT BALLASTS

A. Manufacturers:

1. Philips.

2. Osram.

3. General Electric.

B. Product Description: Electronic ballasts shall be instant start and designed for the type and quantity of lamps served. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated. Comply with ANSI C82.11.

## 2.4 FLUORESCENT DIMMING BALLASTS AND CONTROLS

A. Manufacturers:

1. Philips.

2. General Electric.

3. Lutron.

B. Product Description: Electrical assembly of control unit and ballast to furnish smooth dimming of fluorescent lamps.

C. Control Unit: Selected for energy efficiency and daylight harvesting capability.

D. Ballast: Selected by dimming system manufacturer as suitable for operation with control unit and suitable for lamp type and quantity specified for luminaire.

## 2.5 LED LAMPS

A. Manufacturers:

1. Lighting Science Group.

2. OptiLED.

3. Con-Tech Lighting.

B. Incandescent or halogen lamps not recommended for use on the project unless the lamp life exceeds 10,000 hours. For fluorescent lamps, a color rendering of 80+ CRI, and color temperatures of 2800-3500 Kelvin are preferred.

## 2.6 FLUORESCENT LAMPS

A. Manufacturers:

1. Philips.

2. Osram.

3. General Electric.

2.7 LIGHTING CONTROL SYSTEM

A. Product Description: Complete programmable system allowing for daylight harvesting, DMX-512 fixture control, and interfacing with existing Building Automation Control system in accordance with LEED guidelines.

B. System Commissioning: Provide labor and temporary equipment as required to commission lighting control system in accordance with LEED guidelines.

C. Level Setting: Provide labor and temporary equipment necessary to set and program dimmed and DMX-controlled lighting levels under the Lighting Consultant's supervision.

D. Owner Training: Schedule and provide user training sessions for designated LAWA personnel.

PART 3 - EXECUTION

3.1 EXISTING WORK

A. Disconnect and remove abandoned luminaires, lamps, and accessories.

B. Extend existing interior luminaire installations using materials and methods compatible with existing installations, or as specified.

C. Clean and repair existing interior luminaires to remain or to be reinstalled.

3.2 INSTALLATION

A. Provide labor and materials to install and structurally support fixtures in accordance with all applicable codes and safety practices.

B. Provide additional labor and materials necessary to install color and/or diffusion media in light fixtures as determined by a professional lighting designer. Locate lamps so that they are accessible utilizing standard ladders and lifts.

C. Provide grounding connections to all luminaires within scope of work.

3.3 FIELD QUALITY CONTROL

A. Operate each luminaire after installation and connection. Inspect for proper connection and operation.

3.4 ADJUSTING

A. Provide labor and materials for aiming and adjustment of all fixtures, color and/or diffusion media, and accessories under the Lighting Consultant's supervision.

3.5 CLEANING

A. Remove dirt and debris from enclosures.

B. Clean photometric control surfaces as recommended by manufacturer.

C. Clean finishes and touch up damage.

3.6 PROTECTION OF FINISHED WORK

A. Re-lamp all luminaires that have failed lamps at Substantial Completion.

B. The recommended illumination levels (in footcandles) for the public areas of the Terminals are as follows:

1. Arrival (Exterior) = 5-10FC
2. Artwork and Displays = 40-50FC
3. Back of House Areas
    a. General illumination for working areas = 25-35FC
    b. Corridors and stairways = 5-10FC
4. Baggage Handling = 35-45FC
5. Concessions and Food Courts
    a. General illumination = 15-20FC
    b. Work surfaces = 35-45FC
6. Concourse = 10-15FC
7. Departure (Exterior) = 5-10FC
8. Information Desks = 30-40FC
9. Restrooms = 10-15FC
10. Retail
    a. General illumination = 20-25FC

b. Accenting = 40-50FC

11. TSA / Security

a. General illumination = Per current TSA guideline

12. Ticketing

a. General illumination = 15-20FC

b. Work Surfaces = 35-45FC

END OF SECTION

# SECTION 26 56 00
# EXTERIOR LIGHTING

## PART 1 – GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including Special Provisions and Supplementary Conditions, apply to the Work specified in this Item.

B. June 2011 Los Angeles World Airports Design and Construction Handbook

C. September 2011 LAWA Design Standards

D. Refer to Section 265613, Lighting Poles and Standards, for requirements for lighting poles and standards.

E. Description of Work:

1. The extent of exterior lighting fixture Work is indicated by drawings and in schedules and by the requirements of this Item.

F. Types:

1. The types of exterior lighting fixtures required for the Project include the following:

a. High Intensity Discharge.

G. Applications.

1. The applications of exterior lighting fixtures required for the Project include the following:

a. Outdoor area lighting.

H. June 2011 Los Angeles World Airports Design and Construction Handbook

### 1.2 SUMMARY

A. Section Includes:

1. Exterior luminaires with lamps and ballasts.

2. Luminaire-mounted photoelectric relays.

3. Poles and accessories.

4. Luminaire lowering devices.

B. Related Sections:

1. Division 26 Section "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

## 1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color-rendering index.

C. HID: High-intensity discharge.

D. LER: Luminaire efficacy rating.

E. Luminaire: Complete lighting fixture, including ballast housing if provided.

F. Pole: Luminaire support structure, including tower used for large area illumination.

G. Standard: Same definition as "Pole" above.

## 1.4 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

A. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4-M.

B. Live Load: Single load of 500 lbf, distributed as stated in AASHTO LTS-4-M.

C. Wind Load: Pressure of wind on pole and luminaire and banners and banner arms, calculated and applied as stated in AASHTO LTS-4-M.

1. Basic wind speed for calculating wind load for poles exceeding 70 feet in height is 200 mph.

a. Wind Importance Factor: 1.5.

b. Minimum Design Life: 50 years.

c. Velocity Conversion Factors: 1.5.

## 1.5 SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:

1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.

2. Details of attaching luminaires and accessories.

3. Details of installation and construction.

4. Luminaire materials.

5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.

   a. Testing Agency Certified Data: For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

   b. Manufacturer Certified Data: Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

6. Photoelectric relays.

7. Ballasts, including energy-efficiency data.

8. Lamps, including life, output, CCT, CRI, lumens, and energy-efficiency data.

9. Materials, dimensions, and finishes of poles.

10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.

11. Anchor bolts for poles.

12. Manufactured pole foundations.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Anchor-bolt templates keyed to specific poles and certified by manufacturer.

3. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.

4. Wiring Diagrams: For power, signal, and control wiring.

C. Samples: For products designated for sample submission in the Exterior Lighting Device Schedule. Each Sample shall include lamps and ballasts.

## 1.6 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainability Requirements:

1. Product Data for PD14-MR-11: For sealants, adhesives, paints and coatings, including printed statement of VOC content.

2. Product Data for PD14-MR-11: Specify VOC emission requirements for the shop finished materials, including where applicable primed steel, finished metals, including aluminum and finished steels.

3. Laboratory Test Reports for PD14-MR-11: For sealants, adhesives, paints and coatings, documentation indicating that products comply with the VOC level limits outlined in the SCAQMD Rule 1168 (9 Adhesives and Sealants) and Rule 1113 (Paints and Coatings) and applicable source – specific SCAQMD standards.

## 1.7 INFORMATIONAL SUBMITTALS

A. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations by a professional engineer.

B. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.

C. Field quality-control reports.

D. Warranty: Sample of special warranty.

## 1.8 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires, poles and luminaire lowering devices to include in emergency, operation, and maintenance manuals.

## 1.9 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: One for every 100 of each type and rating installed. Furnish at least one of each type.

2. Glass and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.

3. Ballasts: One for every 100 of each type and rating installed. Furnish at least one of each type.

4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

## 1.10 QUALITY ASSURANCE

A. Manufacturers. Firms regularly engaged in the manufacture of poles and standards of the types and sizes required whose products have been in satisfactory use in similar service for not less than five years.

B. Contractor. A firm with at least three years of successful installation experience on projects with electrical installation work similar to that required for the Project.

C. NEC Compliance. Comply with the latest edition of the National Electrical Code (NFPA No. 70) as applicable to location and installation of poles and standards.

D. NEMA Compliance. Comply with applicable portions of National Electrical Manufacturers Association standards pertaining to lighting poles and standards.

E. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.

F. 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. Comply with IEEE C2, "National Electrical Safety Code."

H. Comply with NFPA 70.

## 1.11 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B 660.

B. Store poles on decay-resistant-treated skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch deep. Do not apply tools to section of pole to be installed below ground line.

D. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.

E. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.12 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.

1. Warranty Period for Luminaires: Five years from date of Substantial Completion.

2. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.

3. Warranty Period for Color Retention: Five years from date of Substantial Completion.

4. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide product indicated on Drawings.

2.2 GENERAL REQUIREMENTS FOR LUMINAIRES

A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

1. LER Tests HID Fixtures: Where LER is specified, test according to NEMA LE 5B.

B. Lateral Light Distribution Patterns: Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

C. Metal Parts: Free of burrs and sharp corners and edges.

D. Sheet Metal Components: Corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.

E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.

G. Exposed Hardware Material: Stainless steel.

H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

I. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

J. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.

2. Specular Surfaces: 83 percent.

3. Diffusing Specular Surfaces: 75 percent.

K. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

L. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

M. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present,

from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."

2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

a. Color: As selected by Architect from manufacturer's full range.

N. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

a. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.

b. Color: Medium bronze.

O. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp and ballast characteristics:

a. "USES ONLY" and include specific lamp type.

b. Lamp diameter code (T-4, T-5, T-8, T-12), tube configuration (twin, quad, triple), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.

c. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.

d. Start type (preheat, rapid start, instant start) for fluorescent and compact fluorescent luminaires.

e. ANSI ballast type (M98, M57, etc.) for HID luminaires.

f. CCT and CRI for all luminaires.

## 2.3 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

A. Comply with UL 773 or UL 773A.

B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.

1. Relay with locking-type receptacle shall comply with ANSI C136.10.

2. Adjustable window slide for adjusting on-off set points.

## 2.4 BALLASTS FOR HID LAMPS

A. Comply with ANSI C82.4 and UL 1029 and capable of open-circuit operation without reduction of average lamp life. Include the following features unless otherwise indicated:

1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.

2. Minimum Starting Temperature: Minus 22 deg F.

3. Normal Ambient Operating Temperature: 104 deg F.

4. Ballast Fuses: One in each ungrounded power supply conductor. Voltage and current ratings as recommended by ballast manufacturer.

B. Auxiliary, Instant-On, Quartz System: Factory-installed feature automatically switches quartz lamp on when fixture is initially energized and when momentary power outages occur. System automatically turns quartz lamp off when HID lamp reaches approximately 60 percent of light output.

C. High-Pressure Sodium Ballasts: Electromagnetic type with solid-state igniter/starter and capable of open-circuit operation without reduction of average lamp life. Igniter/starter shall have an average life in pulsing mode of 10,000 hours at an igniter/starter-case temperature of 90 deg C.

1. Instant-Restrike Device: Integral with ballast, or solid-state potted module, factory installed within fixture and compatible with lamps, ballasts, and mogul sockets up to 150 W.

a. Restrike Range: 105- to 130-V ac.

b. Maximum Voltage: 250-V peak or 150-V ac rms.

2. Minimum Starting Temperature: Minus 40 deg F.

## 2.5 HID LAMPS

A. Pulse-Start, Metal-Halide Lamps: Minimum CRI 90, and CCT color temperature 4000 K.

B. Ceramic, Pulse-Start, Metal-Halide Lamps: Minimum CRI 80, and CCT color temperature 4000 K.

## 2.6 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS

A. Structural Characteristics: Comply with AASHTO LTS-4-M.

1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.

2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.

B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.

1. Materials: Shall not cause galvanic action at contact points.

2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

3. Anchor-Bolt Template: Plywood or steel.

D. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws. Provide on all, except wood poles.

E. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."

F. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.

G. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4-M.

## 2.7 STEEL POLES

A. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig; one-piece construction up to 40 feet in height with access handhole in pole wall.

1. Shape: Round, tapered.

2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

B. Steel Mast Arms: Single-arm type, continuously welded to pole attachment plate. Material and finish same as pole.

C. Brackets for Luminaires: Detachable, cantilever, without underbrace.

1. Adapter fitting welded to pole, allowing the bracket to be bolted to the pole mounted adapter, then bolted together with stainless-steel bolts.

2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.

3. Match pole material and finish.

D. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

E. Steps: Fixed steel, with nonslip treads, positioned for 15-inch vertical spacing, alternating on opposite sides of pole; first step at elevation 10 feet above finished grade.

F. Intermediate Handhole and Cable Support: Weathertight, 3-by-5-inch handhole located at midpoint of pole with cover for access to internal welded attachment lug for electric cable support grip.

G. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

H. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.

I. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present,

from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or with SSPC-SP 8, "Pickling."

2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.

3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

   a. Color: As selected by Architect from manufacturer's full range.

## 2.8 ALUMINUM POLES

A. Poles: Seamless, extruded structural tube complying with ASTM B 429/B 429M, Alloy 6063-T6 with access handhole in pole wall.

B. Poles: ASTM B 209, 5052-H34 marine sheet alloy with access handhole in pole wall.

1. Shape: Round, tapered.

2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

D. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

E. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.

1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.

2. Finish: Same as pole.

F. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

2. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I,

integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.

a. Color: Medium bronze.

## 2.9 POLE ACCESSORIES

A. Duplex Receptacle: 120 V, 20 A in a weatherproof assembly complying with Division 26 Section "Wiring Devices" for ground-fault circuit-interrupter type.

1. Recessed, 12 inches above finished grade.

2. Nonmetallic polycarbonate plastic or reinforced fiberglass, weatherproof in use, cover, color to match pole, that when mounted results in NEMA 250, Type 4X enclosure.

3. With cord opening.

4. With lockable hasp and latch that complies with OSHA lockout and tag-out requirements.

B. Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover.

C. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

D. Transformer Type Base: Same material and color as pole. Coordinate dimensions to suit pole's base flange and accept ballast(s).

# PART 3 – EXECUTION

## 3.1 LUMINAIRE INSTALLATION

A. Install lamps in each luminaire.

B. Fasten luminaire to indicated structural supports.

1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

## 3.2 POLE INSTALLATION

A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:

1. Fire Hydrants 15 FEET

2. Storm Drainage Piping: 60 inches.

3. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet.

4. Trees: 15 feet from tree trunk.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-Place Concrete."

D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.

1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.

2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.

3. Install base covers unless otherwise indicated.

4. Use a short piece of 1/2-inch- diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Embedded Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.

1. Make holes 6 inches in diameter larger than pole diameter.

2. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi at 28 days, and finish in a dome above finished grade.

3. Use a short piece of 1/2-inch- diameter pipe to make a drain hole through concrete dome. Arrange to drain condensation from interior of pole.

4. Cure concrete a minimum of 72 hours before performing work on pole.

F. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch-wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch below top of concrete slab.

G. Raise and set poles using web fabric slings (not chain or cable).

## 3.3 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Division 26 Section "Raceway and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

## 3.4 GROUNDING

A. Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole unless otherwise indicated.

2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground nonmetallic poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole.

2. Install grounding conductor and conductor protector.

3. Ground metallic components of pole accessories and foundations.

## 3.5 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.

1. Verify operation of photoelectric controls.

C. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IESNA testing guide(s):

a. IESNA LM-5, "Photometric Measurements of Area Lighting Installations."

b. IESNA LM-72, "Directional Positioning of Photometric Data."

D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

## 3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Train Owner's maintenance personnel to adjust, operate, and maintain luminaire lowering devices.

# PART 4 – METHOD OF MEASUREMENT AND PAYMENT

## 4.1 METHOD OF MEASUREMENT

A. Measurement for Exterior Lighting Fixture, Sign Pole, Pole Foundation and Accessories, RON ID Pole and Sign Assembly, Mast Arm Lighting Pole, Pole Foundation and Accessories, and AOA Lighting Pole, Pole Foundation and Accessories shall be per each, which shall include all labor, equipment, materials and incidentals necessary to completely the work as specified in the plans. This cost shall be based on the number of units, fixture heads, its required connections, wall anchors, pole, pole bases, design, calculation, preparation of all installation drawings, coordination, supply of materials, manufacture, delivery to site, installation, quality control, factory and field testing, field coordination, field adjustments and aiming, commissioning, fit-up, trial tests, training, operation and maintenance manuals, furnished and incorporated into the work in accordance with the contract documents.

B. The quantity of each assembly installation to be paid for under this Item shall include: Furnishing and installing floodlights, obstruction lights, pole and pole base, concrete handhole, conductors and disconnect; installed as completed unit, connected to circuit, operating for a minimum of one week burn-in period, ready for operation and accepted.

C. Payment will be made at the contract price per each for the following exterior light fixture assembly, installed and accepted. This price shall be full compensation for furnishing all materials, including floodlights, obstruction lights, pole and pole base, conductors, concrete handhole, control panel and for all labor, equipment, tools, and incidentals necessary to complete these items. The Unit Price for each of these items shall include the Contractor’s overhead, profit and markup.

## 4.2 BASIS OF PAYMENT

A. Payment for exterior lighting shall be made at the contract unit price of each lighting system, where price and payment constitute full compensation for all labor, materials, equipment, testing, and supervision for a complete and functional installation. No separate payment will be made for permits, expenses associated with factory inspection and testing located beyond established parameters, and certification is to be included in the contract unit price.

B. Payment will be made under:

265636.1 Exterior Lighting Fixture – per each

265636.2 Mast Arm Lighting Pole, Pole Foundation and Accessories – per each

# PART 5 – WARRANTY

## 5.1 WARRANTY

A. This contractor shall provide a one-year written warranty against defects in material and workmanship furnished under this contract. The costs of such warranty shall be part of the purchase price. The warranty commences when the Los Angeles Building and Safety Department, and LAWA accepts the total installation.

B. The warranty shall include all necessary material, travel, labor and parts to replace defective components or materials at the job site. This contractor shall comment repair of any, "in warranty" defects within 18 hours of notification of such defects.

C. The warranty shall include all necessary factory and field items required to perform the specified tasks.

## 5.2 PREVENTIVE MAINTENANCE

A. This contractor shall provide a one-year written preventive maintenance to maintain the equipment in working conditions. The one-year written preventive maintenance commences when the Los Angeles Building and Safety Department and LAWA accept the total installation.

B. The one-year written preventive maintenance shall include all necessary material, travel, labor and parts to maintain all components of the installation in working conditions.

END OF SECTION

# SECTION 270500 – BASIC TELECOMMUNICATION REQUIREMENTS

## PART 1 - GENERAL

### 1.1 SCOPE OF WORK

A. A. Work covered by this Section shall consist of furnishing labor, equipment, supplies, materials, and testing unless otherwise specified, and in performing the following operations recognized as necessary for the installation, termination, and labeling of conduit sleeves as described on the Drawings and/or required by these specifications.

### 1.2 RELATED SECTIONS

A. Division 27, Section 271100 Telecommunication Room Buildout Requirements

### 1.3 SUMMARY

A. Section Includes:

1. Communications equipment coordination and installation.
2. Sleeves for pathways and cables.
3. Sleeve seals.
4. Grout.
5. Common communications installation requirements.

### 1.4 GLOSSARY

A. ANSI American National Standards Institute

B. ASME American Society of Mechanical Engineers

C. ASTM American Society for Testing Materials

D. BFU Board of Fire Underwriters

E. BICSI Building Industry Consulting Services International

F. CSA Canadian Standards Association

G. DEC Department of Environmental Conservation

H. EIA Electronics Industry Association

I. EPDM: Ethylene-propylene-diene terpolymer rubber.

J. ER Equipment Room

K. FCC Federal Communications Commission

L. FM Factory Mutual

| | | |
|---|---|---|
| M. | IEEE | Institute of Electrical and Electronics Engineers |
| N. | ISD | Information Systems Division |
| O. | ISO | International Standards Organization |
| P. | LB | Electrical Elbow with accessible coverplate |
| Q. | NBR: | acryloNitrile-Butadiene Rubber. |
| R. | NEC | National Electrical Code |
| S. | NEMA | National Electrical Manufacturers' Association |
| T. | NESC | National Electrical Safety Code |
| U. | NFPA | National Fire Protection Association |
| V. | OSHA | Occupational Safety and Health Administration |
| W. | RUS | Rural Utility Service (formerly REA) |
| X. | TIA | Telecommunications Industry Association |
| Y. | UFBC | Uniform Fire Prevention and Building Code |
| Z. | UL | Underwriter's Laboratories, Inc. |

1.2 DEFINITIONS

A. Throughout the specifications, abbreviations may be used. The following are brief definitions of many of those abbreviations.

| | | |
|---|---|---|
| 1. | Approved / Approval | Written permission to use a material or system. |
| 2. | As Called for | Materials, equipment including the execution specified/shown in the Specifications. |
| 3. | Code Requirements | Minimum requirements. |
| 4. | Concealed | Work installed in pipe and duct shafts, chases or recesses, inside walls, above ceilings, in slabs or below grade. |
| 5. | Exposed | Work not identified as concealed. |
| 6. | Final Acceptance | Owner acceptance of the project from Contractor upon certified by Owner's Representative. |
| 7. | Furnish | Supply and deliver to installation location. |
| 8. | Furnished by Others | Receive delivery at job site or where called for and install. |
| 9. | Inspection | Visual observations by Owner or Owner's Representative. |
| 10. | Install | Mount and connect equipment and associated materials ready for use. |
| 11. | Listed | Refers to classification by a standards agency. |

| | |
|---|---|
| 12. Or Approved Equal | Approved equal or equivalent as determined by Owner or Owner's Representative. |
| 13. Owner's Representative | Design professional or Consultant representing the Owner. |
| 14. Provide | Furnish, install and connect ready for use. |
| 15. Relocate | Disassemble, disconnect and transport equipment to new locations; then clean, test and install ready for use. |
| 16. Replace | Remove and provide new item. |
| 17. Review | A general contractual conformance check of specified products. |
| 18. Satisfactory | As specified in Specifications. |

1.5 SUBMITTALS

A. Product Data: For sleeve seals.

1.6 COORDINATION

A. Coordinate arrangement, mounting, and support of communications equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To allow right of way for piping and conduit installed at required slope.
4. So connecting pathways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for communications items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."."

PART 2 - PRODUCTS

2.1 SLEEVES FOR PATHWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.

2.3 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.

2. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

3. Sealing Elements: interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of pathway or cable.
4. Pressure Plates: Include two for each sealing element.
5. Connecting Bolts and Nuts: Of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.4 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

2.4 FIRE STOPPING

A. Fire stopping for openings through fire-rated and smoke-rated walls and floor assemblies shall be listed or classified by an approved independent testing laboratory for "Through-Penetration Fire Stop Systems." The system shall meet the requirements of "Fire Tests of Through-Penetration Fire Stops" designated ASTM E814.

B. Inside of all conduits, the fire stop system shall consist of dielectric, water resistant, non-hardening, permanently pliable/re-enterable putty along with the appropriate damming or backer materials (where required). The sealant must be capable of being removed and reinstalled and must adhere to all penetrants and common construction materials and shall be capable of allowing normal wire/cable movement without being displaced.

C. All conduit and sleeve openings used by the Contractor shall be waterproofed or fireproofed in compliance with State and Local Building and Fire Codes. Strict adherence to National, State, and Local Fire Codes, particularly fire stopping will be required.

D. The Contractor shall patch all openings remaining around and inside all conduit, sleeves and cable penetrations to maintain the integrity of any fire rated wall, ceiling, floor, etc. The fire stop system shall consist of a dielectric, water resistant, non-hardening, permanently pliable/re-enterable putty along with the appropriate damming materials (where required). The sealant must be capable of being removed and reinstalled and must adhere to all penetrants and common construction materials and shall be capable of allowing normal wire/cable movement without being displaced.

E. All building conduits and sleeves installed and/or used under this Specification shall be fire stopped, or re-fire stopped, upon cable placement through such passageways.

F. Manufacturer's recommended installation standards must be closely followed (i.e. minimum depth of material, use of ceramic fiber and installation procedures).

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR COMMUNICATIONS INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both communications equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

## 3.2 SLEEVE INSTALLATION FOR COMMUNICATIONS PENETRATIONS

A. Communications penetrations occur when pathways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 4 inches (100 mm) above finished floor level.

G. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pathway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants".

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pathway and cable penetrations. Install sleeves and seal pathway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

K. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work. Prior to installation, verify existing warranty of roof with THE OWNER and Plant Facility personnel.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals. Ensure installed sleeve is sloped towards outside to prevent rain/snow water seepage through pipe.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between pathway or cable and sleeve for installing mechanical sleeve seals.

## 3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

## 3.4 FIRESTOPPING

A. Fire stopping for Openings through Fire and Smoke Rated Wall and Floor Assemblies:

1. Provide materials and products listed. The system shall meet the requirements of "Fire Tests of Through-Penetration Fire Stops" designated ASTM E814. To be used inside all conduits and sleeves. Caulk on exterior of conduit penetration.

2. Provide fire stop system seals at all locations where conduit, fiber, cable trays, cables/wires and similar utilities pass through or penetrate fire rated wall or floor assembly. Provide fire stop seal between sleeve and wall for drywall construction.

3. The minimum required fire resistance ratings of the wall or floor assembly shall be maintained by the fire stop system. The installation shall provide an air and watertight seal.

4. The methods used shall incorporate qualities that permit the easy removal or addition of conduits or cables without drilling or use of special tools. The product shall adhere to itself to allow repairs to be made with the same material and permit the vibration, expansion and/or contraction of any items passing through the penetration without cracking, crumbling and resulting reduction in fire rating. Typical rating:

   a) floors - 3 hours

   b) corridor walls - 2 hours

   c) offices - ¾ hour

   d) smoke partitions - ¾ - 1 hour

5. Provide fire stop pillows for existing cable tray penetrations through firewalls.

END OF SECTION 270500

# SECTION 271101 - TELECOMMUNICATIONS ROOM AND SPACES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

### 1.2 RELATED SECTIONS

A. Division 27, Section 270500 Basic Telecommunication Requirements

### 1.3 SUMMARY

A. This Section includes minimum requirements for equipment, termination hardware, and cable installation in communication equipment rooms including, but not limited to:

1. Floor mounted passive relay racks.
2. Floor mounted active equipment relay racks.
3. Wall mounted cabinets.
4. Floor mounted cabinets.
5. Cable management hardware.
6. Ladder racks.
7. Patch panels – Category 6
8. Fiber optic adapter panels, 6 adapters per panel.
9. Fiber optic distribution unit 3U rack mounted.
10. Plywood Backboards.
11. 110 system blocks.
12. UTP cross connects.
13. Grounding and bonding.
14. Powerstrip Telecommunications Room active equipment relay rack.
15. Powerstrip Telecommunications Room equipment cabinets.
16. Optical fiber patch cords - multimode.
17. Optical fiber patch cords – single mode.
18. Category 6 patch cords.
19. 110 system patch cords – Category 6.

### 1.4 SUBMITTALS

A. Product Data: For features, ratings, and performance of each component specified.

B. Submit manufacturer’s instructions for storage, handling, protection, examination, preparation, operation, and installation of products. Include application conditions or limitations of use stipulated by any product testing agency. Submit for the following:

1. Floor mounted relay racks.
2. Wall mounted relay racks and brackets.
3. Wall mounted cabinets.
4. Floor mounted cabinets.
5. Cable management hardware.
6. Cable supports and ladder racks.
7. Patch panels
8. Fiber system blocks.
9. Power strips.
10. Patch cords.

C. Shop Drawings:

1. Component List: List manufacturer, part number, and quantity of each component.
2. Include dimensioned plan and elevation views of equipment rooms, labeling each individual component. Show equipment rack assemblies, method of field assembly, workspace requirements, and access for cable connections.

## 1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 Certified, for components that are required to have submittals provided as part of this Section.

B. Installer Qualifications:

1. A firm currently engaged and which has been continuously engaged for the past 5 years in the installation of low voltage applications of type required for this Project, and which is licensed in and has obtained or will obtain the necessary permits to perform telecommunications installations in jurisdiction where Project is located.
2. Have a BICSI certified RCDD locally on staff
3. Provide references of the type of installation provided in this specification.
4. Have personnel knowledgeable in local, state, and national codes and the latest TIA Telecommunications Standards and Manufacturer's recommendations.
5. Have personnel fluent in the use of AutoCAD version 2002 or later and possess and operate CAD software capable of producing .DWG or .DXF format.

C. Source Limitations: Obtain units of the same type of equipment through one source from a single manufacturer.

D. Product Options: Drawings indicate size, profiles, and dimensional requirements of equipment, accessories, and components and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

1. Do not modify intended aesthetic effects or performance, as judged solely by Architect, except with Architect's approval. If modifications are proposed, submit comprehensive explanatory data to Architect for review.

E. Materials and labor shall comply with applicable requirements of following standards, using latest version of associated appendices and Technical Service Bulletins at the time of award of the Contract;

1. EIA/TIA-568.
2. EIA/TIA-569.
3. EIA/TIA-606.
4. EIA/TIA-607.
5. Underwriter's Laboratory.
6. FCC (including CFR 47 and Part 68 – Subpart F).
7. National Electric Code.
8. Local and State Codes.
9. ISO/I/EC 11801.
10. IEC 1000-5-2.
11. IEC 60603-7.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.
2. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

### 2.2 FLOOR MOUNTED RELAY RACKS

A. Physical Specifications:

1. 19 inch (482.6 mm) rack mounting space.
2. 84 inches (2134 mm) high.
3. Lightweight, high strength aluminum construction.
4. Black powder coat finish.
5. 15 inch (381 mm) deep base with 4 3/4 inch (19 mm) bolt down holes.
6. EIA channel width of 3 inches (76 2 mm), with #12-24 screw holes.
7. Rack shall have double sided #12-24 tapped holes and EIA universal rack 5/8 inch (16 mm) to 5/8 inch (16 mm) – 1/2 inch (12.7 mm) standard hole pattern (compatible with 1-1/4 inch (32 mm) – 1/2 inch (12.7 mm) hole patterns).

B. Approved Manufacturers:

1. Hoffman
2. APW
3. Chatsworth Products Inc.
4. Other approved equal submitted in advance as required in SOW

## 2.3 WALL MOUNTED CABINETS

A. Physical Specifications:

1. 19 inch (482.6 mm) equipment mounting space.
2. 42 to 48 inches (1067 to 1219 mm) high.
3. Universal mounting rails with 12/24 tapped holes.
4. 5/8 inch (16 mm) to 5/8 inch (16 mm) – 1/2 inch (12.7 mm) standard hole pattern.
5. Black powder coat finish.

B. Racks shall have:

1. A 2 hinge design for front and rear access
2. Louvered sides for ventilation
3. Knockouts in top and bottom for cable access
4. Both front and rear access shall be lockable
5. Smoked Plexiglas Door

C. Approved Manufacturers:

1. Hoffman
2. APW
3. Chatsworth Products Inc.
4. Other approved equal submitted in advance as required in SOW

## 2.4 FLOOR MOUNTED CABINET

A. Physical Specifications:

1. 0.0556 inch (1.41 mm) thick steel construction.
2. Capable of setting equipment mounting rails at 19 inches (483 mm).
3. Nominal 84 by 24 by 40 inches (1956 by 610 by 1016 mm).
4. Lockable smoked Plexiglas hinged door on front and steel hinged door in rear.
5. Vented roof.
6. Removable side panels.
7. Leveling feet.
8. Raised floor cabinet installation components.

B. Approved Manufacturers:

1. APC
2. Other approved equal submitted in advance as required in SOW

## 2.5 CABLE MANAGEMENT FOR RELAY RACKS

A. Cable management shall be black metal or plastic with integral wire retaining fingers.

B. Vertical management panels shall have front and rear channels.

C. Vertical cable management panels shall have removable front and back covers made of black metal.

D. A horizontal crossover cable manager shall be provided as shown on Drawings for each relay rack, with minimum height of 1 rack units each.

E. Approved Manufacturers:

1. Panduit
2. Hoffman
3. Chatsworth Products Inc.
4. Other approved equal submitted in advance as required in SOW

## 2.6 FIBER OPTIC SC and LC-DUPLEX ADAPTER PANELS, 6 ADAPTERS PER PANEL

1. Adapter shall support a minimum of 6 adapters per panel and shall permit termination in increments of 6 strands of fiber.
2. Adapter shall permit the installation of 2 duplex SC and/or LC type connectors to be installed, such that the 2 appear to function as one connector in quantities and type as shown on the drawings.

A. Approved Manufacturers:

1. Commscope
2. Berktek
3. Corning
4. Other approved equal submitted in advance as required in SOW

## 2.7 PATCH PANELS – CATEGORY 6

A. Termination panels shall support appropriate Category 6 applications and facilitate cross-connection and inter-connection using modular patch cords.

B. Sized to fit an EIA standard, 19-inch (482.6 mm) relay rack, or be capable of mounting to wall.

C. Accommodate a minimum of 48 ports for each rack mount space, where 1 rack mount space is equal to 1.75 inches (44.5 mm).

D. Have circuit boards tested in both directions as required by ANSI/TIA/EIA-568 and ISO/IEC 11801.

E. Have angle left and angle right modules to provide optimum cable management.

F. Have removable 6 port modules to allow replacement in field.

G. Have Category 6 jacks available in both T568A and T568B wiring schemes, with 110-style termination.

H. Allow for minimum of 200 re-terminations without signal degradation below standards compliance limit.

I. Have modular ports compliant with FCC CFR 47 part 68 Subpart F and IEC 60603-7 with 50 microinches (0.0013 mm) of gold plating over nickel contacts or equivalent.

J. Have plastic strip for physical protection of printed circuit board.

K. Have port identification numbers on both the front and rear of panel.

L. Provide clear label holders and white designation labels with panel, with optional color labels available.

M. Be made by an ISO 9001 Certified Manufacturer.

N. Electrical Specifications:

1. Meet ANSI/TIA/EIA-568-B.2-1 Category 6 component specifications.
2. Meet following requirements:

| TIA/EIA-568-B.2-1 Category 6 Compliant; ISO/IEC 11801, 2nd ed. Category 6 Compliant | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Freq. (MHz) | Ins. Loss (dB/100m) | NEXT Loss (dB) | PSNEXT Loss (dB) | ACR (dB) | PSACR (dB) | ELFEXT (dB) | PSELFEXT (dB) | Return Loss (dB) |
| 1 | 2.1 | 75.5 | 73.5 | 73.5 | 71.5 | 71.0 | 68.0 | 20.2 |
| 4 | 3.9 | 66.5 | 64.5 | 62.7 | 60.7 | 59.0 | 56.0 | 23.2 |
| 8 | 5.4 | 62 | 60.0 | 56.7 | 54.7 | 52.9 | 49.9 | 24.7 |
| 10 | 6.1 | 60.5 | 58.5 | 54.5 | 52.5 | 51.0 | 48.0 | 25.2 |
| 16 | 7.7 | 57.4 | 55.4 | 49.8 | 47.8 | 46.9 | 43.9 | 25.2 |
| 31.25 | 10.8 | 53.1 | 51.1 | 42.4 | 40.4 | 41.1 | 38.1 | 23.8 |
| 62.5 | 15.5 | 48.6 | 46.6 | 33.2 | 31.2 | 35.1 | 32.1 | 21.7 |
| 100 | 19.9 | 45.5 | 43.5 | 25.7 | 23.7 | 31.0 | 28.0 | 20.3 |
| 200 | 29.1 | 41 | 39.0 | 12.0 | 10.0 | 25.0 | 22.0 | 18.2 |
| 250 | 32.9 | 39.5 | 37.5 | 6.7 | 4.7 | 23.0 | 20.0 | 17.8 |
| 350 | 39.9 | 37.3 | 35.3 | - | - | 20.1 | 17.1 | 17.3 |
| 400 | 42.9 | 36.5 | 34.5 | - | - | 19.0 | 15.9 | 16.9 |
| 500 | 48.1 | 35.9 | 33.9 | - | - | 16.9 | 13.9 | 16.3 |
| 550 | 50.7 | 34.8 | 33.6 | - | - | 15.8 | 13.1 | 15.8 |

3. Be UL verified for TIA/EIA Category 6 electrical performance.
4. Steel frame with black powder coat finish in 24 and 48 port configurations.
5. Have port identification numbers on both front and rear of panel.
6. Have mounting slots compatible with ANSI/EIA-310.
7. Allow modular insert to accept 110-style patch plugs as means of termination.
8. T-568B wired.
9. Provide 48 port panels, unless otherwise noted.
10. Density must accommodate maximum of 24 ports per single rack unit (1.75 inch (44.5 mm)).
11. Paired punch down sequence to allow pair twist within 1/2 inch (12.7 mm) of termination.
12. Relay rack mounted.
13. UL listed, compliant with FCC CFR47, Part 68 Subpart F and IEC 60603-7, with 50 microinches (0.0013 mm) of gold plating over nickel contacts, or equivalent.

14. Allow use of 4 or 5 pair impact termination tool.
15. Have port identification numbers on front and rear of panel.
16. Provide port configurations and densities as indicated on Drawings.
17. Provide rear cable management bar(s) as recommended by manufacturer.
18. Shall be insulation displacement connector 110 style terminations.
19. Provide EIA/TIA 606 compliant color-coded icons or color-coded designation label strips for all patch panels. Identify voice or data functionality as required.

O. Approved Manufacturers:

1. Commscope
2. Leviton
3. Ortronics
4. Other approved equal submitted in advance as required in SOW

## 2.8 FIBER OPTIC DISTRIBUTION UNIT 3U RACK MOUNTED

A. All panels and trays (units) shall provide cross-connect, inter-connect, splicing capabilities and contain cable management for supporting and routing fiber cables and jumpers.

B. Feature a front access design with hinged bulkhead plate.

C. Use adapter plates that house a minimum of 6 adapters SC-Duplex each.

D. Use of MPO or MPT as alternative for approval

E. Have blank adapter plates for future growth of fiber infrastructure.

F. Have hinged removable front cover.

G. Have integrated vertical cableway on one side of panel.

H. Be 19 inch (483 mm) rack mountable.

I. Have storage and splicing options as part of product offering.

J. Be made by ISO 9001 certified manufacturer.

K. Provide port configurations and densities as indicated on Drawings.

L. Approved Manufacturers:

1. Commscope
2. Corning
3. Ortronics
4. Other approved equal submitted in advance as required in SOW

## 2.9 BACKBOARDS

A. Plywood backboards will be provided by others unless stated otherwise in the Contract Documents and/or Drawings. All walls within a TR will be required to be covered with ¾" AC rated plywood. Plywood shall be fire treated (stamp must remain visible if painted) and painted with two coats of fire retardant paint to match room color. Sheets must be installed lengthwise originating 6 inches above finished floor height.

## 2.10 DISTRIBUTION RINGS

A. Provide open end distribution rings for wall mounted cross-connect fields above wall mounted blocks. Provide 2 rings per vertical row.

B. Approved Manufacturers:

1. Cooper B-Line
2. Chatsworth
3. Senior Industries
4. Other approved equal submitted in advance as required in SOW

## 2.11 GROUNDING AND BONDING

A. Materials: Comply with NFPA 70, TIA/EIA-607, and UL 467.

B. See drawing package for additional requirements.

C. Comply with manufacturer's grounding requirements.

## 2.12 TELECOMMUNICATIONS POWER STRIP

A. Provide power strips/PDUs as shown on the drawings for each cabinet and rack.

B. Approved Manufacturers:

a. Geist
b. Other approved equal submitted in advance as required in SOW

## 2.13 OPTICAL FIBER PATCH CORDS – MULTIMODE

A. Shall be available in standard lengths of 3, 6, 10, and 16.4 feet (1, 2, 3, and 5 meters), custom lengths shall also be available, and shall meet or exceed standards as defined in ANSI/TIA/EIA-568 and ISO/IEC 11801.

B. For existing environments utilize duplex optical fiber cable that is 62.5/125 micron multimode, OFNR riser grade, and meets the requirements of UL 1666. For new installation environments utilize 50/125 micron multimode fiber. Confirm with the Owner before purchasing cabling.

C. Utilize optical fiber cable where the attenuation shall not exceed 3.5 dB/km at 850 nm wavelength or 1.0 dB/km at 1300 nm.

D. Cable Jacket Color:

1. 62.5/125: Orange.
2. 50/125: Aqua.

E. Be equipped with the connector type as shown on the drawings and in accordance with TIA/EIA-568 and must include a ceramic ferrule.

F. Have terminated connectors exhibit maximum insertion loss of 0.25 dB with average of 0.20 dB or better when tested at either 850 nm or 1300 nm wavelentths for 62/125 µm.

G. Have terminated connectors exhibit maximum insertion loss of 0.25 dB with average of 0.20 dB or better when tested at either 850 nm or 1300 nm wavelengths for 50/125 µm.

H. Have average return loss of 2.5 dB with minimum return loss of 2.0 dB at both 850 nm and 1300 nm.

I. Be made by ISO 9001 certified manufacturer.

J. Be UL 1666 approved.

K. Shall be duplex fiber cable meeting or exceeding transmission characteristics of optical fiber horizontal cable.

L. Following configurations may be required:

1. SC type/SC type
2. ST type/SC type
3. ST Type/LC Type
4. SC Type/LC Type
5. ST Type/ST Type
6. LC Type/LC Type

M. Approved Manufacturers:

1. Corning
2. Commscope
3. Ortronics
4. Other approved equal submitted in advance as required in SOW

## 2.14 OPTICAL FIBER PATCH CORDS – SINGLE MODE

A. Available in standard lengths of 3, 6, 10, and 16.4 feet (1, 2, 3, and 5 meters), custom lengths shall also be available, and shall meet or exceed standards as defined in ANSI/TIA/EIA-568 and ISO/IEC 11801.

B. Be either simplex or duplex OFNR riser grade cable, with attenuation at wavelength 1310 nm being 1.0 dB/km and at wavelength 1550 nm 1.0 db/km.

C. Jacket Color: Yellow.

D. Connectors shall be of the type as shown on the drawings and in accordance with TIA/EIA-568 and must include a ceramic ferrule.

E. Terminated connectors shall exhibit a maximum insertion loss of 0.50 db with an average of 0.25 dB when tested at either 1310 nm or 1660 nm wavelengths for singlemode fiber.

F. Have average return loss of 53 db with minimum return loss of 40 dB at both 1310 and 1550 nm.

G. Be made by ISO 9002 certified manufacturer.

H. Be UL 1666 approved.

I. Approved Manufacturers:

1. Corning
2. Commscope
3. Ortronics
4. Other approved equal submitted in advance as required in SOW

## 2.15 CATEGORY 6 PATCH CORDS

A. Shall be round, and consist of 8 insulated 24 AWG stranded copper conductors arranged in 4 color-coded twisted-pairs within flame-retardant jacket.

B. Be equipped with modular 8-position plugs on both ends, wired straight through with standards compliant wiring.

C. Use modular plugs, which exceed FCC CFR 47 Part 68 Subpart F and IEC 60603-7 specifications, and have 50 microinches (0.0013 mm) minimum of gold plating over nickel contacts.

D. Be resistant to corrosion from humidity, extreme temperatures, and airborne contaminants.

E. Utilize cable that exhibits power sum NEXT performance.

F. Be available in several colors with or without color strain relief boots providing snag-less design.

G. Meet flex test requirements of 1000 cycles with boots and 100 cycles without boots.

H. Be available in any custom length and standard lengths of 3, 5, 7, 10, 15, 20, and 25 feet (.9, 1.5, 2.1, 3, 4.6, 6.1, and 7.6 m).

I. Be made by ISO 9001 certified manufacturer.

J. Electrical Specifications:

1. Input Impedance Without Averaging: 100 ohms plus or minus 15 percent from 1 to 100 MHz.
2. One hundred percent transmission tested for performance up to 100 MHz. Manufacturer shall guarantee cords are compatible with Category 6 links.

3. Utilize cable that is UL verified (or equivalent) for TIA/EIA Category 6 electrical performance.
4. UL listed 1863.

K. Horizontal Workstation Colors:
1. All horizontal cabling will consist of Plenum rated cable regardless of Plenum environment and will be Blue in color.

L. Approved Manufacturers:

1. Commscope
2. Leviton
3. Ortronics
4. Other approved equal submitted in advance as required in SOW

## PART 3 - EXECUTION

### 3.1 FLOOR MOUNTED RELAY RACKS

A. Anchor racks to floor using drop anchor with bolt to match diameter of mounting hole in base of rack.

B. Provide vertical and horizontal cable as indicated on Drawings.

C. Mount with minimum 36 inch (915 mm) clear access behind and in front of rack rows but maintain 48 inches between wall and rack.

D. Install equipment ground bus bar in rack for systems integrator or installer to ground equipment per grounding details on drawings. Ground rack equipment ground bus bar to room ground bus bar with #6 copper wire.

E. Provide grounding, earthing, and bonding in accordance with applicable codes and regulations, with the requirements of IEC 1000-5-2, and ANSI/TIA/EIA-607.

### 3.2 WALL MOUNTED RELAY RACKS

A. Secure racks to building structure with approved anchoring means for the type of wall being attached to. Always mount ¾” plywood backboard to wall first and then attach rack. Use full sheet of plywood attached to wall attached to a minimum of two separate studs. Paint plywood to match room color.

B. Verify existing wall construction and submit proposed anchoring methods for Owner approval.

C. Provide vertical and horizontal cable management both front and rear wherever available.

D. Must be lockable cabinet with matching keys.

## 3.3 CABLE MANAGEMENT

A. Provide horizontal cable manager at top and bottom of each relay rack, with minimum height of two rack units each.

B. Alternate patch panel and wire management starting from top of rack with wire manager on top.

C. Provide 2 rear cable management bars and reusable Velcro-type hook and loop straps in each rear vertical channel. Reusable straps shall be of varying sizes, each allowing 50 percent spare future expansion, and of adequate quantity to secure cable bundles at least every 4 rack units.

D. Secure cable managers, slack managers, support bars, and hook and loop straps per manufacturer's recommendations.

## 3.4 CATEGORY 6 PATCH PANELS

A. Install and label as recommended by manufacturer, per EIA/TIA 606A.

B. Install rear cable management bars as recommended by manufacturer.

## 3.5 OPTICAL FIBER PATCH PANELS

A. Install as indicated on Drawings.

B. Install blank adapter panels in positions not used at time of installation for fiber terminations.

## 3.6 CABLE SUPPORTS

A. Provide "D" rings 24 inches (610 mm) on center for exposed wall mounted vertical Category 6 cable runs.

B. To maximum extent possible, horizontal wall runs shall be on wall mounted ladder racks. Minimize horizontal wall mounted cable runs.

C. Provide cable brackets 36 inches (914 mm) on center supported to building structure for cable runs not supported by cable tray.

## 3.7 BACKBOARDS

A. Use full sheet of plywood attached to wall attached to a minimum of two separate studs. Paint plywood to match room color. In telecom rooms, install plywood vertically on all four walls a minimum of 6 inches above finished floor and 6 inches away from all corners.

B. Verify existing wall construction and submit proposed attachment methods for Owner approval.

## 3.8 DISTRIBUTION RINGS

A. Install distribution rings for cross-connect fields above all wall mounted blocks. Provide 2 rings per vertical row of blocks. Mount rings with 2 hex head screws per ring.

## 3.9 MISCELLANEOUS REQUIREMENTS

A. Cables in Equipment Rooms shall be neatly “dressed out” and accessible.

B. Provide service loops on cables terminated in Telecommunications Rooms as indicated on Drawings.

C. Firestop sleeves and conduit openings after cable installation is complete. See Section 270500 for more firestopping details.

## 3.10 GROUNDING AND BONDING

A. See Section 270526 for Grounding Details

B. See drawing package for additional requirements.

C. Comply with manufacturer’s grounding requirements.

END OF SECTION 271101

# SECTION 272100: LOCAL AREA NETWORKS

## 1.1 PART 1 GENERAL

## 1.2 WORK INCLUDED

A. The Contractor shall provide all equipment, materials, labor, and design and coordination services necessary to complete or perfect all parts of the Local Area Networks (hereafter referred to as data network or network), and to ensure that they are in compliance with requirements stated or reasonably inferred by this Specification. Wherever herein the term provide or provided is used it shall be defined as procure, install and program as required for a fully functional and correctly operational System. All equipment under this Section shall be provided, maintained and operated during the construction and implementation period, tested and commissioned by Contractor.

B. The Contractor shall perform all required coordination with stakeholders to finalize all functional, operational, and performance requirements of the network design. This shall include, but not be limited to, site investigation and verification, design workshops, coordination meetings, and review workshops. Interim and final design documentation shall be submitted for review and approval by Design Professional prior to proceeding with any installation work.

## 1.3 RELATED SECTIONS AND DOCUMENTS

A. General and Supplementary Conditions Sections 00700 and 00800, Division 00 and 01 Sections and other Sections of Divisions 26 and 27

B. Division 28

1. Section 282300 Video Management System

2. Section 282329 Video Devices

## 1.4 SCOPE OF WORK

A. Minimum data Communication Network requirements and installation methods are included for the following:

1. Network Switches

2. Network Management Equipment

3. Provisioning and Programming

4. Network Equipment Maintenance

B. This Section describes a data network that shall serve as the communications and data transfer method used by the new Video Management System (VMS) described in Section 282300.

Approximately 100 Internet Protocol (IP) CCTV cameras access this network for transport, viewing, storage and archive.

C. Contractor responsible for this Section shall coordinate with the VMS vendor for compression algorithm proposed, system bandwidth calculations and QoS requirements.

D. Data network of this Section shall be required to support both unicast and multicast video streaming and multiple video streams from each individual CCTV camera. Contractor shall coordinate with VMS vendor and then configure the network to support the various camera requirements.

E. Data network shall be designed to accommodate a minimum of 10,000 devices.

F. The new VMS shall be integrated with the existing access control system (ACS) to allow for automatic camera call up on user selected alarm criteria. This contractor shall connect and configure all required servers, and configure VLANS and firewalls as indicated herein, in Division 28 Sections and on construction drawings.

G. The Network configuration is expected to be multifaceted with full fail-over redundancy, equipment specific security features, integration with network security software, network management integration and highly available networks.

H. Because the new data network will utilize existing equipment it is required to be installed in a phased manner. Contractor shall provide a proposed phasing plan for approval by Design Professional.

## 1.5 DESIGN AND PERFORMANCE REQUIREMENTS

A. The data network shall be designed using Ethernet switches and Firewalls as shown on the Contract drawings.

B. Data network equipment shall be furnished and installed in accordance with this section and as indicated on the contract drawings.

C. The data network shall provide redundant paths for all network connections as depicted in the contract drawings, and redundant power supplies in all switches such that any single failure will not impact the communication system data transmission.

D. The path protection mechanisms shall be able to protect from any one of the failure types:

1. Hard link condition

2. Node failure

3. Degrade condition such as packet loss or CRC errors greater than a threshold

E. Contractor shall integrate to an existing Network Management System to support the new network which shall include the following functionalities:

4. Status of working and protecting paths

5. Signaling of events that represents changes of status of the working and protection resources

6. A failure event, which causes protection switch, shall trigger an alarm to be raised by the Network Management system.

F. The data network shall provide the necessary interfaces, resiliency and performance to support the various communications system on the networks as indicated on the Contract drawings

G. All communication systems running on the data network shall run concurrently and seamlessly. Problems in any system running on the data network shall not impact any of the other systems on the data network.

H. Contractor who installs this data network shall be responsible for configuring all IP address and subnet schema, VLANS, access control lists (ACL), RADIUS and all necessary Active Directory configuration to allow single log on authentication to the new VMS and all its applications.

I. The data network shall provide the necessary capabilities and configurations to securely and redundantly connect to the networks as depicted on the Contract Drawings.

J. Maintenance and Testing functions running on the networks shall not impact the communications performance of the network.

K. The data network shall have the ability to allow expansion in whole or in part, without interruption of active communication among the operational nodes. Replacement of any single node shall be transparent to the overall system operation.

L. The data network equipment shall be standard off-the-shelf products and shall employ route diversity to achieve multi-path physical redundancy.

M. All data network equipment shall be of the most highly developed technology currently available and in a state of common usage, in manufacture and performance. All equipment shall utilize standard, commercially available products. Equipment shall be modular with plug-in hardware and cabling to facilitate maintenance and expansion to the fullest extent possible. The equipment shall include necessary components and software required for a complete and operable network. All software products which are not site specific, or otherwise specified commercially available packages (such as operating systems, equipment programming and configuration software, etc.) shall be manufactured by the data network equipment manufacturer, as part of their standard product offering and shall not be custom produced for this application. This standard product software shall be modular in structure, enabling future system upgrades for additional capabilities to be easily accomplished, by installation of software updates without requiring modification of the existing system configuration.

N. The data network equipment shall be designed for full time, 24 hour, seven days a week operation.

O. When connected to any of the existing networks indicated on the Contract Drawings, the data network shall not degrade the performance, availability, reliability or manageability of these existing networks.

P. The data network shall be designed such that equipment within the existing networks does not require upgrades to support new network protocols.

Q. In order to connect the data network to the existing networks indicated on the Contract Drawings, the data network shall conform to the existing network connection specifications.

R. The data network shall have the capability to be logically segmented into Permanent Virtual circuits and/or Virtual Private Networks (VPN) in order to segment traffic based on application and/or priority level such that high volume traffic applications or transient traffic does not impact or degrade other systems performance.

## 1.6 QUALITY ASSURANCE

A. All equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the Specification shall be subject to the control and approval of the Design Professional. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based on the acceptable manufacturers listed. Where "or equal" is stated, equipment shall be equivalent in every way to that of the equipment specified, and subject to approval.

B. All equipment, Routers, Switches & Hubs shall be manufactured by a single manufacturer.

C. The contractor shall certify that all proposed equipment shall comply completely with all of the requirements of this Contract.

D. The data network equipment installer staff used on this project shall have manufacturer's training and be certified and factory authorized in the installation of all backbone communications system equipment.

E. The Contractor shall examine the design and specifications of all systems on the network, in detail, and take responsibility to complete the installation and insure that all systems performance and bandwidth requirements are met.

## 1.7 SUBMITTALS

A. Submittals shall be in accordance with Section 013300 Submittal Procedures and Section 018800.

B. In accordance with the overall project schedule, submit interim and final design documentation of the data network for review and approval by the Design Professional.

C. Submit a detailed bill-of-materials listing all manufacturers, part numbers, and quantities that the Bidder proposes to use in this project.

D. Submit a proposed construction Phasing Plan and receive approval from Design Professional prior to commencing Work.

1.8 DELIVERY, STORAGE AND HANDLING

A. Deliver material in manufacturers' original unopened protective packaging.

B. Store materials in original packaging in a manner to prevent soiling, physical damages, wetting or corrosion prior to installation.

C. Handle in a manner to prevent damage to finished surfaces.

D. Where possible, maintain protective coverings until installation is complete and remove such covers as part of final cleanup.

E. Touch up any damage to finishes to match adjacent surfaces to the satisfaction of Design Professional.

PART 2 PRODUCTS

2.1 MANUFACTURER

A. Any items that are not shown in Appendix A that are needed to meet the requirements of this Section and to provide a fully functional and accepted data network shall be provided by Contractor.

1. Contractor is responsible for receiving, unloading, and handling other furnished items at Project site.

2. Contractor is responsible for protecting other furnished items from damage during storage and handling, including damage from exposure to the elements.

3. If other furnished items are damaged as a result of Contractor's operations, Contractor shall repair or replace them.

2.2 MATERIALS

A. All equipment and materials furnished as work of this contract shall be new and unused. Equipment shall be of the latest technology, first grade commercial quality and shall be the standard cataloged products. Only those items specifically shown on the Contract Drawings as existing relocated or Authority furnished, if any, shall be reused. Use of rebuilt or remanufactured equipment shall not be permitted.

B. Provide network equipment as specified in this section and on the Contract Drawings. If product or series is no longer manufactured or has been designated by Cisco as End of Life, then furnish the latest Cisco update or equivalent. All substitutions shall be approved by Design Professional.

2.3 ETHERNET SWITCHES

A. The Ethernet switches shall be provided for networks in support of the communications and computer systems shown on the Contract Drawings.

B. All Ethernet Switches shall include the following requirements:

1. Shall be rack mountable.

2. Shall be furnished with redundant power supplies.

3. Shall support 10BASE-T/100BASE-TX ports: RJ-45 connectors; four-pair Category 6 UTP cabling.

4. Shall support 100BASE-LX ports: LC connectors; 50/125, 62.5/125 micron for Multi-Mode or 9/125 single-mode fiber-optic cabling.

5. Shall at a minimum operate in the following environmental conditions:

a) Operating Temperature: 32 degrees F to 104 degrees F (0 degrees C to 45 degrees C).

b) Storage Temperature: minus 13 degrees F to 158 degrees F (minus 25 degrees C to 70 degrees C).

c) Relative Humidity: 10 to 85 percent, non-condensing.

6. Shall support the following protocols:

a) 802.1D - Standard for Local and Metropolitan Area Networks Media Access Control (MAC) Bridges

b) 802.1P - Traffic Class and Dynamic Multi-Cast Filtering Services in Bridged Local Area Networks (Draft Supplement to 802.1D)

c) 802.1Q - Virtual Bridged Local Area Networks

d) IEEE 802.1w Rapid Spanning Tree Protocol (RSTP) and Per VLAN Rapid Spanning Tree (PVRST plus)

e) 802.3AD - Standard for Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications Aggregation of Multiple Link Segments

f) IGMP snooping for IP Multicast support and Per-port broadcast, multicast, and unicast storm control.

g) PIM-SM, PIM-DM and PIM-SM/DM to support Multicast network traffic.

h) Resilient Ethernet Protocol (REP)

i) Cisco Spanning-Tree Protocol enhancements including: UplinkFast, BackboneFast, and PortFast.

j) HSRP (Hot Standby Redundant Protocol)

k) The aggregate QoS model by enabling classification, policing/metering, and marking functions on a per-port basis at ingress and queuing/scheduling functions at egress.

l) SNMP (Simple Network Management Protocol).

m) Non-blocking configuration of simultaneous wire-speed switching across all ports.

n) Operate from 120VAC, 60Hz.

7. Switches shall include the following requirements (as required for location used):

a) Ethernet switches shall be provided with:

1. 12 SFP Gigabit Ethernet ports and 2 X2 10 Gigabit Ethernet ports

2. Management console port: RJ45

3. 12 SFP based Gigabit Ethernet ports + 2 X2-based 10 Gigabit Ethernet ports

4. 68 Gbps, wire rate backplane

5. Dual hot-swappable 300WAC or DC power supplies and redundant field-replaceable fans

6. 1-RU fixed configuration multilayer switch

7. IPv6

8. IP Services software feature set (IPS)

9. Provides full IPv6 dynamic routing

8. Switches shall include the following requirements (as required for the location used):

b) The Ethernet switches shall have the following connectors and shall use cabling as follows:

10. 10/100/1000 BASE-T ports: RJ-45 connectors, 2-pair CAT 6 unshielded twisted-pair (UTP) cabling.

11. 1000 Base BX SFP: 1310 nm single-mode fiber or 1000 Base BX SFP : 850 nm multimode

12. Management console port: RJ-45-to-DB9 cable for PC connections.

    a) Enterprise-class intelligent services delivered to the network edge. The power supply shall support input voltages between 100 and 240 VAC.

    b) The power connector shall offer connection for an optional Cisco RPS (Redundant Power Supply) 675 that uses 120 VAC input and supplies DC output to the switch.

    c) The power connector shall automatically sense when the internal power supply of a connected device fails and provides power to the failed device, preventing loss of network traffic.

13. Integrated Power over Ethernet (PoE) IEEE 802.3af Compliant.

a) The Ethernet switches shall support the following protocols:

1. Gigabit Ethernet: IEEE 802.3z.

2. 1000BASE-X (GBIC): 1000BASE-SX; 1000BASE-LX/LH; 1000BASE-ZX.

3. Power over Ethernet (PoE): IEEE 802.3af.

b) Redundant hot swappable power supplies.

c) Switching modules used shall be selected from among the following or approved equals:

1. Switched 10/100 Fast Ethernet (RJ-45), (Port Density: 240).

2. Switched 10/100 Fast Ethernet (RJ-45) with IEEE 802.3af.

3. Power over Ethernet (PoE) (Port Density: 240).

4. Switched 10/100 Fast Ethernet (RJ-21) (Port Density: 240).

5. Switched 100 FX Fast Ethernet (MT-RJ) (Port Density: 240).

6. Switched 1000 Gigabit Ethernet (fiber) (Port Density: 244).

7. Switched 10/100/1000BASE-T Gigabit Ethernet (Port Density: 240).

8. Switched 10/100/1000BASE-T Gigabit Ethernet with IEEE 802.3af PoE (Port Density: 240).

9. Switched 10,000 (10 Gigabit Ethernet) (Port Density: 2).

## 2.4 FIREWALLS

A. The Firewall shall be Cisco ASA 5500 series Enterprise Editions

B. All Firewall switches, along with their data specifications shall be submitted to the Design Professional for approval to determine if they are appropriate for the designed application.

C. All firewalls shall include the following features:

1. Logging and notification ability

2. High volume packet inspection

3. Ease of configuration

4. Device security and redundancy

5. Updated service from manufacturer for 12 months minimum.

2.5 NETWORK TIME PROTOCOL (NTP) SERVER:

A. The data network shall be provided with a common time synchronization source so that all attached system servers and other network devices are time synchronized. Provide a Stratum 1 NTP server which utilizes CDMA or GPS synchronization technology which can be monitored with SNMP protocol (End Run Technologies Praecis CNTP with CDMA or equivalent).

2.6 PATCH CORDS

A. Contractor shall provide all necessary UTP and fiber patch cords to interconnect all data network components.

B. UTP patch cords shall be Category 6 rated, ,terminated with Category 6 rated RJ-45 plugs and sized for the length required

1. Supply one patch cord for every connection needed between RJ-45 patch panels and network switches

C. Fiber patch cords shall be singlemode or multimode as required by fiber transceiver being used and shall be terminated with LC type connectors and sized for the length required.

2.7 NETWORK MANAGEMENT SYSTEM REQUIREMENTS

A. The NMS shall provide state of the art functionality that includes, but not limited to the following features:

1. Graphical display of the network devices with the status indications.

2. Automatic network mapping of physical layer (devices, ports).

3. Monitoring of device condition, performance, environmental status, and traffic load.

4. Display of the traffic (complete content of packets) or protocol information gathered from operator selected port or logical connection on a router.

5. Support of SNMP, version 1, 2 and 3; polling intervals of devices shall be at user configurable intervals; the NMS shall be able to incorporate MIB extensions for each managed device.

6. Ability for operator to make changes in device configurations directly from the NMS console.

7. In addition to any primary console, the NMS shall offer multi-user access to a single NMS server through a web-based client. Users shall have configurable access scope and authorizations based on at least role, user name, and time of day.

8. The NMS shall be compatible with or integrated with configuration management and policy setting features that allow services, connections, and performance parameters to be configured in all affected devices by issuing a higher level command from the console. For example, the NMS shall configure all switches and routers on a connection path to create a logical connection and assign it a bandwidth guarantee, latency cap, security level (isolation or encryption), or other properties as desired between two specific ports, logical or physical.

9. The NMS shall recognize virtual LANs.

10. NMS shall send page alerts via WCTP, SNPP when switches go down or are rebooted and shall notify operators when switches or interfaces acquire high response time, high packet lost, etc.

11. NMS to provide the following reports on demand: switch/interface availability, performance, traffic load.

2.8 NETWORK MANAGEMENT SYSTEM PERFORMANCE REQUIREMENTS

A. The NMS shall support:

1. The selected manufacturer’s network equipment and shall function with and be compatible with the existing network infrastructure and management systems (CiscoWorks and HP Open View).

2. Management of at least three thousand (3000) network devices with response to common commands (change of display, drill down view, etc.) in less than five (5) seconds.

3. Provide storage for historical statistics for at least two years.

B. Servers running the NMS shall be capable of a redundant configuration wherein the failure of any single device, up to an entire server, shall not render the NMS function unavailable to any operator.

PART 3 EXECUTION

3.1 GENERAL

A. System installation and construction methods shall conform to the requirements of the State of Missouri and as stated in General and Special Conditions of the Contract Documents.

B. System installation and construction methods shall conform to the requirements of the Federal Communications Commission.

C. The Contractor shall install all system components including furnished equipment, and appurtenances in accordance with the manufacturer's instructions, NFPA 70, ANSI-C2 and as shown, and shall furnish all cables, connectors, terminators, interconnections, services, and adjustments required for a complete and operable system.

1. Interconnection wiring between components mounted in the same rack or cabinet does not need to be installed in conduits.

D. Grounding shall be installed as necessary to preclude ground loops, noise, and surges from adversely affecting system operation.

E. For equipment mounted in drawers or on slides, provide the interconnecting cables with a service loop of not less than three feet and ensure that the cable is long enough to allow full extension of drawer or slide.

## 3.2 EXAMINATION

A. Verify that electrical installations, structural, mechanical and other related work satisfy the requirements for performance of the Work of this section in accordance with the Contract Drawings.

B. Before delivering the equipment to the site, the Contractor shall investigate the site conditions to determine the best method of shipment, what preparatory work, if any, will be needed to bring the equipment onto the site and method of unloading the equipment and setting it in place.

C. Report immediately to the Design Professional any electrical, structural or related construction defects in areas where equipment are to be installed, and do not attempt to rectify any defect unless specifically instructed to do so by the Design Professional.

D. Before unloading the equipment it shall be inspected for damage during the shipment. Any damage shall immediately be brought to the attention of the Design Professional for resolution.

E. Before the data network Equipment installation, the communications cable infrastructure shall be inspected and tested as part of the Work, The results of this testing shall be reviewed by the data network Integrator, who shall verify its suitability for the data network equipment and that losses are within the equipment specs for operations. Any no conformity shall be brought to the attention of the Design Professional.

## 3.3 INSTALLATION

A. Install all switches, power supplies and cords, fiber and UTP patch cables, and other appurtenances as required for a complete and functional system.

B. Install all fiber patch cords in all telecommunications rooms and data center required to connect all switches together. Patch end-to-end fiber circuits between all rooms and patch panels as shown construction drawings to provide total end-to-end connection.

3.4 ACCEPTANCE TESTING

A. Factory, performance and acceptance tests shall be conducted in accordance with Section 018800. Submit test plans for approval by Design Professional that cover all requirements of this Section and show that the data network meets or exceeds all requirements.

B. Network shall be tested under real or simulated full load conditions and shall include a fail-over test to verify network redundancy features.

3.5 HARDWARE INSTALLATION

A. Design plans for hardware selection, installation location, and installation details shall be provided for Design Professional approval.

B. Installation of hardware shall be coordinated with the Design Professional.

C. The Contractor shall ensure the ventilation requirements for all hardware components are met.

D. The Contractor shall install and inspect all hardware required to fully meet the functional, operational and performance requirements of the data network identified in the specification. Installation of hardware shall be in accordance with the manufacturer's installation instructions.

3.6 LABELING

A. Label all cabled with certification tags complying with EIA/TIA standards specifications. Provide ptouch labels on connector panel cover indicating what ports are associated with what connection point (no hand written labels are allowed). See example of label text below:

1. SECURITY NETWORKK – TB1 4506 – FOPP C1/P1 TO TB6 6509 – FOPP C5/P1

3.7 PHASES OF IMPLEMENTATION

B. The Contractor shall adhere to security systems installation Phasing Plan requirements when implementing the network components.

3.8 TRAINING - GENERAL

A. Relevant system specific user, maintainer and technical training shall be provided as detailed in Section 018800.

3.9 MAINTENANCE

A. Provide maintenance in accordance with Section 01 88 00.

B. Remote management of the data Communications Network shall be via call-back modem only. Network access via the Internet shall not be included.

END OF SECTION

# SECTION 27310 - DATA COMMUNICATIONS WIRELESS ACCESS POINTS (AP)

## PART 1 GENERAL

### 1.01 WORK INCLUDED

A. The Contractor shall provide all equipment, materials, labor, and design and coordination services necessary to complete or perfect all parts of the Data Communications Wireless Access Points (AP) (802.11 [a, b/g, n]), and to ensure that they are in compliance with requirements stated or reasonably inferred by this Specification, and the Construction Drawings.

### 1.02 SCOPE OF WORK

A. This section includes the minimum requirements for Data Communications Wireless Access Points which includes the IEEE 802.11 (a, b/g, n) specifications.

B. Minimum Data Communications Wireless Access Point requirements and installation methods are included for the following:

1. Standards and Architecture
2. Access Points
3. Management
4. Security
5. Scalability
6. Availability
7. Virtual IP Networks
8. Voice and Video
9. Reports, Logs, and Traces
10. Site Survey
11. Specifications

### 1.03 QUALITY ASSURANCE

A. All equipment installed for IT Systems shall be done in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the Specification shall be subject to the control and approval of the Architect/Engineer. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based on the acceptable manufacturers listed. Where "approved equal" is stated, equipment shall be equivalent in every way to that of the equipment specified, and subject to approval.

B. Contractor Qualifications

1. The contractor shall adhere to the engineering, installation and testing procedures provided by the manufacturer and utilize the authorized manufacturer components and distribution channels in provisioning this Project.
2. The contractor shall provide three references for projects of equivalent scope, type and complexity of work completed within the last three years.

C. Hardware manufacturer's experience:

1. All components shall be produced by manufacturers who have been regularly engaged in the production of wireless access points of the types to be installed in this project for a period of five years.

D. Materials and work specified herein shall comply with the applicable requirements of:

- ANSI/TIA/EIA-568-B.1
- ANSI/TIA/EIA-568-B.1-1
- ANSI/TIA/EIA-568-B.2
- ANSI/TIA/EIA-568-B.2-1 to 2-6
- ANSI/TIA/EIA-568-B.3
- ANSI/TIA/EIA-568-B.3-1
- ANSI/TIA/EIA-569-A
- ANSI/TIA/EIA-569-A-1 to A-7
- ANSI/TIA/EIA-606
- ANSI/TIA/EIA-607
- ANSI/ICEA S-90-661
- ANSI/EIA/TIA-492AAAA
- ANSI/TIA/EIA-472CAAA
- ANSI/TIA/EIA-472DAAA
- ANSI/TIA/EIA-598
- ANSI/TIA/EIA-598A-C
- ANSI/TIA/EIA-455
- ANSI/TIA/EIA-604
- ANSI/TIA/EIA-526
- ANSI/ICEA S-80-576
- ANSI/ICEA S-83-596
- ANSI/ICEA S-83-640
- ISO/IEC 11801
- ISO/IEC JTC 1/SC 25/WG 3 N655 (Nov. 2001)
- CENELEC EN50173
- IEC 603-7
- BICSI
- National Life Safety Code, NFPA 101.
- NFPA 70 – 2005 or newer.
- NEC – Articles 770 and 800.
- UL.
- FM.
- BICSI Telecommunications Distribution Methods Manual.
- IEEE Standards.
- Federal Communications Commission.
- RUS Standards (formerly REA).
- Customer Environmental Health and Safety Standards.
- Americans with Disabilities Act (ADA).
- Local State Uniform Fire Prevention and Building Code.
- Local State Department of Labor Rules and Regulations.
- Local State Department of Health.

1.04 SUBMITTALS

A. In accordance with the overall project schedule, submit interim and final design documentation of the wireless Access Point (AP) system for review and approval by the Architect/Engineer.

B. Submit manufacturers' data sheets for proposed products.

C. Submit manufacturers' instructions for storage, handling, protection, examination, preparation, operation, and installation of all products. Include any application conditions or limitations of use stipulated by any product testing agency (submit with Bid).

D. Submit all applicable Material Safety Data Sheets.

E. Submit all testing plans (factory, acceptance, and endurance) for review and approval prior to the performance of any testing.

F. Submit a detailed bill-of-materials listing all manufacturers, part numbers, and quantities that is proposed to be used in this project.

G. Submit a proposed construction Phasing Plan and receive approval from the Architect/Engineer prior to commencing Work

1.05 WARRANTY

A. The warranty on all cabling and connecting hardware of the distribution system to this specification shall be for a period of not less than five years. The connecting hardware shall have a lifetime extended warranty against defects in material and workmanship. If items supplied as part of this project have longer warranties, Contractor shall supply longer warranty.

B. The warranty on all distribution electronics, including taps and passives of the distribution system to this specification shall be for a period of not less than one year. If items supplied as part of this project have longer warranties, Contractor shall supply longer warranty.

C. The warranty shall cover the replacement or repair of defective product(s) and labor for the replacement or repair of such defective product(s).

PART 2 – PRODUCTS

2.01 GENERAL

A. In addition to the requirements specified herein, the AP's shall meet the requirements of section 272100, Local Area Networks.

2.02 802.11 WIRELESS EQUIPMENT SPECIFICATION S

A. RF Management:

1. RF management shall be set to restrict performance-impacting operations such as channel changes when voice over IP traffic is present.

B. User Bandwidth Control:

1. The bandwidth contract shall be implemented to ensure that one single user cannot monopolize bandwidth and can limit users to a maximum amount of bandwidth. Bandwidth contracts can be specified by user role for simple administration, and can be applied per-user (one user cannot exceed 2Mbps, for example) or per-group (all guest users together cannot exceed 2Mbps.)

C. Privacy Protection:

1. AP's shall contain no configuration, passwords, encryption keys, or security information. The AP shall have no exposed serial port, no recoverable passwords, no vendor-installed certificates, and no way for an intruder to tap into the wired side of the AP to eavesdrop on wireless communication.

2. AP's shall be FIPS-140 Level 2 compliant.

D. Simplified Management:

1. The system shall be manageable through a single interface and a single web-based URL. Each of these devices shall have a software image, configuration file, and run-time statistics, as well as different configuration and operation commands.

2. The system shall not require a separate management appliance or software package for basic functionality such as RF visualization, location tracking, or multi-controller management.

E. Security:

1. All security functionality shall be centralized and housed in the mobility controller (including encryption) and not the AP, guaranteeing that AP does not have to be replaced as security standards evolve to protect the investment, and ensure the continuous security of the network.

F. Application Bandwidth Control:

1. The system shall support a stateful protocol inspection for voice protocols with automatic mapping to bandwidth control and quality of service schemes. These schemes shall limit the maximum bandwidth and/or guarantee a minimum bandwidth, latency, and jitter for an application. This way, a mixed-use wireless network can support both voice and data with both getting sufficient resources.

G. User/device Controls:

1. The system shall support the ability to restrict the types of protocols on a wireless LAN, as well as to restrict the types of resources a wireless device can access (for example, the system permits administrators to block or restrict client-to-client communication, dramatically reducing malicious attacks, viruses, and worms).

2. The system shall possess the ability to allow modification of network access permissions at any time during the life of a session, based on both internal controls and integration with external systems through SNMP, syslog, XML, and RADIUS.

H. Secure Guest Access:

1. The system shall differentiates between internal users and guest users through integrated authentication, encryption, and authorization. All three functions shall be managed by the mobility controller. The external firewall, knowing users only through IP addresses, will pass the traffic into the network.
2. The system shall not be vulnerable to such an attack, making it safe to deploy internal and guest users on the same infrastructure.

I. Integrated Intrusion Protection:

1. The system shall supports a wireless intrusion detection system that is integrated with the wireless infrastructure. By placing these two functions in the same device, the system becomes a protection system rather than simply a detection system.
2. The system shall detect then lock out rogue APs, ad-hoc networks, bridges, DoS attacks, man in the middle attacks, impersonation attacks, and many others.

J. Users shall be capable of using wired access, wireless access, remote access, or a combination of these accessed.

K. Extended policy criteria shall be capable of making access control decisions based on parameters, such as identity, physical location, time of day, authentication method, device type, device integrity state, protocol, and application. Put in more general terms, a per-packet access control decision can be made based on:

1. Who the user is
2. How the user is accessing the network
3. Where the user is
4. When the access is made
5. What resource the user is trying to access

## 2.03 MINIMUM FUNCTIONAL SPECIFICTIONS

A. AP shall be capable of the following minimum functional specifications:

1. FIPS 140-2 802.11i, Military Grade L2 Security
2. Domain/Realm AAA Server Control
3. LAN Speed VPN Authentication/Termination
4. AP VPN/IPSec Tunnels
5. Remote Traffic Bridging with Central/Mgmt
6. Security Extension via 3rd Party (A/V, IPS, etc.)
7. Web-Based/Clientless Scanning/Remediation
8. Virtual Desktop/Clean Erase
9. Identity/Role/Policy-Based Traffic Separation

10. Stateful Access Rights
11. Time, Location Access Policies
12. WiFi Anomaly Thresholds and Blacklisting
13. Advanced Captive Portal / Web-Authentication
14. Complete Intrusion Prevention (All Threats)
15. Integrated Blacklisting & Location Tracking
16. Integral Wired Access Control
17. Advanced Location Tracking & Heatmaps
18. End-to-End QoS/Voice Optimization
19. Remote 802.11 Packet Capture
20. Per User/Device Troubleshooting (RealTime)
21. AP Self Provisioning & Optimization (RealTime)
22. Rogue/Threat Classification
23. Strong/Complete Intrusion Detection
24. Central Authentication, L2/L3 Fast Roaming
25. Rogue Detection/Containment/Location
26. AP Monitoring, Config Mgmt, Reporting (Offline)
27. Multi-SSIDs (Hidden/Broadcast), VLANs, NAT
28. Encryption/Authentication (WPA1.0/2.0)
29. Integral Wired Port Access Control
30. Seamless Small/Branch Site Solution
31. Eliminate Campus LAN Integration
32. End-to-End Data Encryption
33. Auto/Self Provisioning AP’s
34. Real-Time AP RF Optimization/Tuning
35. Dynamic/Smart Load Balancing
36. “Any Device” Location Tracking
37. Client-Client Fire-walling
38. AP Failure Detection/Recovery
39. SMNP Monitoring & Basic Reporting
40. AP Configuration / Update Mgmt
41. Offline Analysis & Config Tuning

42. “Assisted” AP Install/Configuration
43. Advanced, Stand-alone Access Point
44. Multiple SSID’s
45. VLANs, NAT, DHCP, 1 x Radio Adjustments

## 2.04 SITE SURVEY

A. A full "site survey" of the buildings by the winning bidder shall be conducted in order to determine and document the exact number, placement, and coverage of access point devices and the type of antenna required by each. The respondent shall carry out and document the survey at its cost, working closely with designated employees. Detailed drawings and wiring-closet locations will be provided to the winning bidder.

B. Access Point Category 6 UTP cabling is provided by the DAS cabling contractor. Refer to Specification 275300.

# PART 3 – EXECUTION

## 3.01 GENERAL REQUIREMENTS

A. System installation and construction methods shall conform to the requirements of the State of California and as stated in Divisions 0 and 1 of the Contract Documents.

B. System installation and construction methods shall conform to the requirements of the Federal Communications Commission.

C. Contractor shall install equipment to meet seismic requirements of the State of California and as stated herein.

1. Where undefined by codes and standards, Contractor shall apply a safety factor of at least 2 times the rated load to all fastenings and supports of system components.

D. The Contractor shall install all system components including furnished equipment, and appurtenances in accordance with the manufacturer's instructions, NFPA 70, ANSI-C2 and as shown, and shall furnish all cables, connectors, terminators, interconnections, services, and adjustments required for a complete and operable system.

1. Interconnection wiring between components mounted in the same rack or cabinet does not need to be installed in conduits.

## 3.02 HARDWARE INSTALLATION

A. Design plans for hardware selection, installation location, and installation details shall be provided for Engineer approval.

B. Installation of hardware shall be coordinated with the Engineer.

C. The Contractor shall ensure the ventilation requirements for the all hardware components are met.

D. The Contractor shall install and inspect all hardware required to fully meet the functional, operational, and performance requirements of the Integrated IT Systems identified in this Specification. Installation of hardware shall be in accordance with the manufacturer's installation instructions.

3.03 TRAINING

A. Contractor shall provide any training necessary for use, administer and/or maintenance of the in-building distribution system. Contractor is to coordinate with the Employer on time and place for training. Training sessions are to accommodate personnel schedules. Training shall include familiarization with radio equipment settings and configuration

END OF SECTION

# SECTION 275300 – DISTRIBUTED ANTENNA SYSTEM

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section 275300 contains the technical specifications for a Distributed Antenna System (DAS) at the Los Angeles International Airport Consolidated Rental Car (ConRAC) Facility Complex Buildings A, B, C, D and E.

B. The system configuration described herein shall provide Wide-Band 150MHz to 2700MHz Neutral-Host Active Distributed Antenna System (DAS) for in-building rebroadcast of wireless 2G, 3G, and 4G LTE Mobile services, and a separate fully independent DAS for in-building rebroadcast of TETRA wireless Trunked Radio services as per below specifications.

C. DAS shall be compliant with the Federal Communications Commission (FCC) requirements, but not limited to, the following Frequencies (MHz):

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Band Freq (MHz) | UHF 350-470 | iDEN 800 | GSM 900 | GSM 1800 & LTE 1800 | UMTS 2100 | LTE 2300 | LTE 2600 |
| | TETRA (TETRA & DMR) | Band 20 (EU Dig DiV) - FDD | Band 8 (E-GSM) - FDD | Band 3 (DCS) - FDD | Band 1 (IMT) - FDD | Band 40 - TDD | Band 38 - TDD |

D. The Point of Interface (POI) between the Mobile DAS and macro Mobile network shall be defined as at the output of the Mobile Base Station(s) provided by at least four (4) local Mobile Service Providers.

E. The POI between the TETRA DAS and TETRA Systems shall be defined as the output of the TETRA Base Station(s) or IP-BASED Remote TETRA Terminal provided by at least three (3) TETRA Systems.

F. The Building A, Quick- Turnaround Area (QTA) Level 1 Zone MPOE shall house all Mobile Base Station equipment and TETRA Base Station / IP-BASED Remote Terminals, which will be provided by their respective providers. The room shall also house the DAS POI and DAS head-end equipment for Mobile and TETRA, which shall be provided by this contract.

1. Required Power, HVAC, and UPS equipment for the MPOE will be provided by others; however, sizing/capacity requirements shall be coordinated by the DAS equipment provider for all head end equipment provided under this contract.

G. Single mode fiber optic cabling will be provided by others to support connectivity between the DAS head-end master equipment, any intermediate fiber optics distribution units, and to remote antenna unit equipment; however, fiber optic cables sizing/capacity requirements shall be coordinated by the DAS equipment provider for all equipment provided under this contract

H. Electrical Power will be provided in MPOE, Secondary Unit locations and Remote Unit locations by others.

1.2 SCOPE OF WORK

A. The Distributed Antenna System (DAS) shall provide 2G/3G/4G LTE 2x2 MIMO Mobile and 1x1 SISO TETRA in-building rebroadcast coverage for the ConRAC Complex.

B. Mobile DAS rebroadcast and TETRA DAS rebroadcast shall be provided by fully separate independent systems.

C. Future Proofing: Wide Band DAS Mobile and TETRA solutions shall be provided to allow changes to modulation technologies and provision of additional modulation technologies from 150MHz to 2.7GHz frequencies without the need for equipment component replacement or upgrade of head-end master unit, secondary unit, remote unit or antennas.

D. The Mobile and TETRA DAS solutions shall be based on separate active equipment using Fiber-optic backbone and horizontal fiber optics distribution that connects multiple zones within the terminal and multiple buildings with multi/single floor configurations to the centralized Head-end located in the MPOE (QTA, Level 1).

E. The DAS Mobile and TETRA solutions shall be modular systems capable of adding modules and remote units to allow expansion of the DAS coverage, with no practical limits to the quantity of DAS antenna locations allowed on the system.

F. The DAS Mobile solution shall be capable of supporting additional Mobile Operators including, but not limited to different bands and different modulation.

G. The DAS Mobile and TETRA solutions shall utilize singlemode fiber cores compliant with all ITU-T G.652.D performance parameters including maximum attenuation of 0.4 Db/Km @ 1310nm (OS2) as the transmission media for all interconnections. Total passive fiber losses of each fiber link between end-to-end active equipment channel shall not exceed 5dB, including all splices, connectors and patching. Where total passive fiber loss measurements exceed 5dB, fiber connectivity shall be re-terminated, re-spliced, rerouted, modified to eliminate patching, connectors, splices; and/or re-terminated using angled polish connectors (APC) and patch cords as required to achieve total passive loss requirements.

H. The DAS shall provide a high level of service within various areas of the ConRAC Complex, but the minimum level of service shall meet the following minimum criteria:

1. For all publicly accessible areas of the ConRAC Buildings, 4G LTE 2X2 MIMO service shall be guaranteed with Mobile signal level of at least -65 dBm.
2. For the ConRAC Complex non-public operational areas such as office and support areas, a minimum Mobile signal level of -75 dBm shall be provided.
3. For operational areas that are not routinely occupied or areas that are used for rental car operations such as storage or areas with vehicular traffic, the ability to utilize voice services shall be maintained with minimum Mobile signal power of -85 dBm
4. For all ConRAC Complex indoor areas, TETRA service shall be provided with usable signal coverage for 90% of the general areas and 99% coverage in critical areas as defined NFPA 72. Usable signal shall be defined as -95dBm inbound and outbound signal strength. The Contractor shall demonstrate compliance with these coverage requirements. As per NFPA 72, critical areas shall include the Fire Control Room, exit stairs, exit passageways, elevator lobbies, standpipe cabinets, sprinkler sectional valve locations, and other areas deemed critical by the authority having jurisdiction.

I. The DAS solution shall accept a minimum of four (4) different radio signal inputs including 2G, 3G, iDEN, and separate A and B streams for the 4G LTE 2x2 MIMO. The inputs to the head-end shall provide separate RX and TX ports. Duplexers with precise Uplink/Downlink frequency separation shall be utilized to separate the Base station / NodeB / eNodeB Transceivers signals where required. The DAS head-end shall be comprised of Primary Units that allow for the matrix assignment of specific frequency ranges or services to specific outputs. The Primary unit administrative and monitoring control shall be based on software programmable over the Local Area Network (LAN) connection. The Primary unit shall connect to a minimum of eight (8) fiber optics secondary expansion units. The primary and secondary expansion units shall accept different input and output modules in each port as required to accommodate different configurations. The Secondary expansion units shall accommodate a minimum of eight (8) Active Remote Antenna Units. For all areas that require MOBILE services, the Secondary Expansion Units shall be paired to provide A and B as required for 4G LTE dual streams to support 2X2 Mulitple In Multiple Out (MIMO) configuration. The Remote units shall be active devices that connect to the antennas for the DAS. For all MIMO configurations, there shall be a minimum of two (2) local RUs and two (2) dual polarized dipole antennas with orthogonal separation of Uplink and Downlink within the antenna. Refer to the technical drawings for further configuration details.

J. A complete and fully functional solution for an active Distributed Antenna System (DAS) shall be provided in accordance with the related Specifications, Drawings, Manufacturer's recommendations and requirements, including:

1. Point of Interface (POI) equipment including amplifiers, attenuators, directional couplers, hybrid couplers, combiners, splitters, terminations, DC blocks, diplexers, duplexers, and triplexers as required to combine and adjust power of input signal from Mobile and TETRA Base Station equipment to match the DAS head-end equipment individual input modules at 0 dBm.
2. DAS Head-end equipment including Primary Units and the associated input and output modules.
3. DAS Secondary Expansion Units.
4. DAS Active Remote Antenna Units.

5. DAS Activity Monitoring Tool for Mobile services to allow statistics and billing.
6. Coordination of Fiber Optic cabling to provide connections from the Primary Units to Secondary Units and from the Secondary Units to the Remote Units, which will be provided by others.
7. Patch Cords as required to connect all equipment to the fiber optic backbone and horizontal cable.
8. Low loss coaxial cable from the Remote Units to individual Antennas ports.
9. Low loss coaxial cable from Mobile Base Stations, TETRA Base Station(s) or IP-BASED Remote TETRA Terminal to POI equipment and to the DAS primary head-end equipment.
10. Standard 19-inch Equipment cabinets and enclosures will be provided by others.
11. Fiber Optic Patch Panels will be provided by others.
12. Fiber Termination, management, and Testing will be provided by others.
13. Cable Management equipment for coaxial cables
14. Non-objection certificate approval from each Mobile Operator for rebroadcast.
15. In-building pre-installation survey, post installation survey, and signal optimization.
16. Inter-modulation Study.
17. Project Management, including coordination and planning.
18. Installation, configuration, programming, system grounding, and labeling.
19. Testing.
20. Training.
21. All other work, equipment and components required to provide a complete and fully operational system.
22. Warranty.
23. Ongoing maintenance and repair support.

K. Scope exclusions:

1. The DAS shall not be utilized for WiFi distribution. However, Contractor shall pull an additional Category 6 UTP cable to each DAS antenna location for potential use as a WiFi Access Point. Refer to Section 273100
2. Fiber Optics cabling.
3. Outdoor coverage areas not explicitly shown in the drawings.
4. Electrical Power, backup power provision, and/or standby generator power.
5. Mobile Operator Base Stations / Node B / eNode B or IP/E1/Backhaul circuits.
6. TETRA Base Stations or TETRA IP Remote Terminals.

## 1.3 SUBMITTALS

A. A summary shall be provided listing each manufacturer, model, part number and cut sheet reference page(s) with each product submittal.

B. Provide the following for approval:

1. Approval from each Mobile Operator for rebroadcast based on the proposed solution.
2. Approval by the authority having jurisdiction (AHJ) based on the proposed solution.
3. Permit for public safety radio enhancement by AHJ, where required.

4. RF pre-installation survey.
5. RF post-installation survey.
6. Inter-modulation study.
7. POI Block Diagram.
8. Sector planning including hand-over zones.
9. In-building survey and signal optimization.
10. System detailed layout and link budget calculations.
11. Testing plan including optimization and power configuration plan.
12. Training Plan with course materials.
13. Warranty and optional Extended Warranty.
14. Ongoing maintenance and repair support options.
15. End of Life equipment notifications and proposed replacement.

## 1.4 QUALITY ASSURANCE

A. Depending on state and local regulations, Qualified personnel shall meet at least one of the following requirements:

1. Radio engineers registered, licensed, or certified by the local authority.
2. Certified by a national certification organization acceptable to the AHJ.
3. Factory-trained and certified for design of the specific type/brand of system and are acceptable to the AHJ.

B. System Installers shall be qualified or supervised by persons qualified in the installation, inspection and testing of the system.

C. Service personnel shall be qualified and experienced in the inspection, testing and maintenance of the system. Service personnel may additionally be qualified by employment with an organization listed by a nationally recognized testing laboratory for the servicing of the specific type/brand system.

# PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

A. Subject to compliance with requirements, manufacturers shall meet all specifications requirements and shall be approved by the Engineer.

## 2.2 GENERAL DAS REQUIREMENTS

A. The Contractor shall design, install and optimize two (2) fully functional independent Active DAS systems based on the performance requirements specified herein. Distribution antenna locations

shall be optimized based on locations shown on the drawings. All proposed locations shall be coordinated with the General Contractor and the Construction Manager prior to installation.

B. The same type of system including components, manufacturer, and general architecture shall be provided for the Mobile and the TETRA DAS systems with the exception of 2x2 MIMO architecture for Mobile and 1x1 SISO architecture for TETRA.

C. The Mobile DAS shall support iDEN, 2G, 3G and 4G 3GPP standards including GSM, UMTS, EDGE, HSPA+, and LTE.

D. The DAS head-end shall utilize separate transmit (Tx) and Receive Rx) to establish separate uplink and downlink input signaling connectivity through the DAS system from the POI equipment to the antenna. Duplexers shall be provided to separate the Tx and Rx signals where Base Station outputs are only available as combined transmit and received (TRx).

E. All equipment shall be compatible with simultaneous use of analog and digital communications, and be capable of upgrade to allow future radio frequency changes or additions necessary to maintain radio system coverage.

F. The Contractor shall coordinate with the wireless service providers for the provision of base stations and other service provider equipment as required to allow for rebroadcast of their licensed frequencies on the DAS. The Contractor shall be responsible for coordinating with the wireless service providers to determine the modulation schemes and number and types of services to be distributed. The public safety radio components shall be capable of transmitting all public safety radio frequencies assigned to the jurisdiction and using any modulation type.

G. The maximum system propagation delay for the DAS systems shall be provided by the AHJ.

H. The Contractor shall perform an intermodulation study of the ConRAC Complex, including Wi-Fi and wireless carriers, for all components of the DAS. The Contractor shall provide recommendations to remediate any problems identified in the intermodulation study and re-run the study until all problems have been eliminated. The contractor shall provide corrections to the DAS as required.

## 2.3 SYSTEMS CONFIGURATION

A. The Contractor shall submit shop drawings showing system layout and link budget calculations based on the equipment selected to meet performance criteria in this specification.

B. Radio signals shall be combined, amplified and transported from the head-end location to in-building distributed antenna locations using a combination of active equipment, fiber optic cable, and coaxial cable. The TETRA antennas and equipment shall be separate from other DAS antennas and equipment.

C. Distributed antennas shall be located to minimize interference with and intermodulation between other antennas and other wireless systems. The design as detailed on the drawings include

minimum separation between various antenna types. For TETRA antennas, the send and receive antennas shall be separated by not less than five point two (5.2) meters with preference for 8 meters separation where possible. For Mobile antennas in a MIMO configuration, the send and receive antennas shall be separated by not less than two (2) meters. The Tetra and Mobile antennas shall be separated by not less than five point two (5.2) meters from other antennas to minimize signal interference.

D. All coaxial connected components shall utilize 50 ohm matched impedance and N type connectors and terminators. Head-End components shall be mounted as indicated on the Drawings.

E. All remote unit components including power and communication equipment (both passive and active) shall be placed within ceiling or wall mounted enclosures. The enclosure type and size shall be in accordance with the details as shown on the drawings and varies dependent upon the equipment quantities and locations.

F. Remote Antennas shall provide at least 18dBm EiRP supporting four operators and all mobile bands.

G. RF combining and signal attenuation devices shall be provided as part of the POI equipment to comply with manufacture requirements and recommendations for DAS input signals.

H. Final Sector quantity and assignment to specific DAS head-end systems shall be coordinated with each Mobile Operator. The DAS system design is based on 50% market share for the largest mobile operator during Peak Busy Hour.

I. DAS POI and head-end master units shall be rack mounted in freestanding enclosed and lockable equipment cabinets located in the PTB Main Radio Room. Secondary units shall be rack mounted in freestanding enclosed and lockable equipment cabinets in building Data Rooms or as indicated on the Drawings. All active DAS equipment shall be secured in lockable cabinets or enclosures.

1. The Contractor shall coordinate with Mobile Operators and the relevant Authorities to enable final approval of their equipment selection, Sector assignments and definition and implementation of the appropriate installation process and commissioning tests

## 2.4 SYSTEM COMPONENTS

A. Point of Interface Equipment

1. DAS Carrier Conditioners

a. Provides passive interface between Base Station signaling and DAS head-end equipment.
b. Integrated rack mountable housing consisting of hybrid combiners, diplexers, duplexers, attenuators, terminators, terminators, cables and other passive devices required per the application.
c. Impedance: 50 ohm.

d. Low PIM, High isolation.
e. Adjustable signal power level controls – 30dB in 1dB steps.
f. Monitoring ports.
g. Mounting: 19” standard rack.
h. Connectors: N-type female.

2. Hybrid Couplers

a. Frequency range: 150-2700MHz.
b. Impedance: 50 ohm.
c. Insertion loss 3.2dB.
d. Coupling 3dB.
e. Isolation between input ports: 30dB.
f. Isolation between output ports: 30dB.
g. Return loss: 20dB.
h. Intermodular distortion (PIM): 150 dBc
i. Composite power max: 160 W.
j. Input and output configuration to match to specific application input and output requirements.
k. Connector: N-type female.

3. Diplexers

a. Frequency range: 1-2700MHz (provide specific band frequencies).
b. Impedance: 50 ohm.
c. Pass band loss 0.3dB.
d. Isolation between input ports: 50dB @ 800-2500MHz, 30dB @ 2500-2700MHZ.
e. Return loss: 20dB.
f. Intermodular distortion (PIM): 150 dBc
g. Composite power max: 160 W.
h. Connector: N-type female.

4. Duplexers

a. Frequency range: 1-2700MHz (provide specific band frequencies).
b. Impedance: 50 ohm.
c. Insertion loss 1.0dB.
d. Isolation between Tx and Rx: 65dB.
e. Return loss: 20dB.
f. Intermodular distortion (PIM): 150 dBc
g. Composite power max: 160 W.
h. Connector: N-type female.

B. Primary Unit

1. Frequency Range: 150 MHz to 2.7 GHz, including both FDD and TDD system support.

2. Minimum of four (4) wireless service interfaces each with separate uplink and down link RF connectivity.
3. Minimum of eight (8) optical interfaces each with separate uplink and downlink single mode fiber connectivity to Secondary Units.
4. Non-blocking switch matrix to allow any combination of the incoming wireless services to be output to any or all of the secondary units.
5. Switch matrix shall be software configurable.
6. Unit shall be provided with an Ethernet 10/100 Mbps LAN port – RJ-45 style.
7. Unit shall be SNMP compatible.
8. Primary Unit shall be provided with external interfaces to allow for USB connection and hard wired alarm outputs.
9. Front mounted Status LEDs
10. Rack mountable in a standard 19" cabinet, not more than 3 RU in height.
11. Provide power supplies compatible with 230 VAC; maximum current draw shall not exceed 500 watts maximum; expected power draw with four (4) service modules and eight (8) optical modules shall not exceed 200 watts.
12. Temperature rating: -5 to +45 degree C, 5 to 95% humidity non-condensing.
13. Hot swappable components
14. Primary Unit Service Module:

    a. Input Connector: Two (2) N Type Female
    b. 0 dBm input typical; 15 dBm maximum
    c. Separate RX and TX ports

15. Primary Unit Optical Module:

    a. Connector Type: APC-SC Transmit, PC-SC Receive
    b. LED Status indicators

C. Secondary Expansion Unit

1. Frequency Range: 150 MHz to 2.7 GHz, including both FDD and TDD system support.
2. Optical Module for input from Primary Unit with separate uplink and downlink single mode fiber connectivity.
3. Capable of accepting up to two (2) optical interconnect modules from Primary Unit.
4. Minimum of eight (8) optical interfaces with separate uplink and downlink single mode fiber connectivity to Remote Units.
5. Switch matrix shall be software configurable.
6. Unit shall be provided with an Ethernet 10/100 Mbps LAN port – RJ-45 style.
7. Unit shall be SNMP compatible.
8. Primary Unit shall be provided with external interfaces to allow for USB connection and hard wired alarm outputs.
9. Front mounted Status LEDs
10. Rack mountable in a standard 19" cabinet, not more than 3 RU in height.
11. Provide power supplies compatible with 230 VAC; maximum current draw shall not exceed 500 watts maximum; expected power draw with two (2) optical interconnect modules and eight (8) optical modules shall not exceed 175 watts.

12. Temperature rating: -5 to +45 degree C, 5 to 95% humidity non-condensing.
13. Hot Swappable components
14. Optical Interconnect Module:

    a. Connector Type: APC-SC Transmit, PC-SC Receive
    b. LED Status indicators

D. Remote Antenna Units

1. Frequency Range: 350 MHz to 2.7 GHz, including both FDD and TDD system support.
2. Optical ports for input from Secondary Unit with separate uplink and downlink single mode fiber connectivity.
3. Two (2) 50 Ohm N Type Female connectors: TX and RX
4. Unit shall be SNMP compatible.
5. Status/Traffic LEDs
6. Provide power supplies compatible with 230 VAC; maximum current draw shall not exceed 30 watts maximum per unit.
7. The Remote Unit shall be capable of providing +25 dB gain, adjustable in 1 dB increments, software controllable.
8. Temperature rating: -5 to +45 degree C, 5 to 95% humidity non-condensing.
9. Connector Type: APC-SC Transmit, PC-SC Receive.
10. Hot swappable driver modules.
11. Auto setup and calibration.

E. DAS In-Building Omnidirectional Distribution Antennas (Multi-band):

1. Operating frequency band 790-960 MHz and 1710-2700MHz.
2. Transmit and Receive (Tx/Rx).
3. All 2G, 3G and 4G standards.
4. Gain 2 dB.
5. VSWR: 2.2:1 over full band, 1.8:1 over 806-960 and 1710-2500 MHz.
6. Ceiling mounted, white color
7. Dimensions: 250 mm diameter, 120mm height
8. Weight: Not greater than 0.4 kg
9. Impedance: 50 ohms.
10. Horizontal beamwidth: 360 degree omnidirectional.
11. Vertical beamwidth: 105 to 155 degree 790-960 MHz, 55 to 65 degree 1710-2500 MHz.
12. Maximum Power rating: 100 W
13. Plenum rated pigtail cable.
1. Connector: N-type female.

F. DAS In-Building Omnidirectional 2 Port MIMO (2X2 MIMO LTE) Mobile Distribution Antennas (Multi-band):

1. Operating frequency band 690-960 MHz and 1710-2700MHz.
2. Gain:3.35 dB @700 MHz, 4.4 dB @ 800/900 MHz, 5.0 dB @ 1800/1900 UMTS; 5.6 dB @ 2400/2500 MHz.

3. VSWR: 2.0:1 maximum over full band
4. Isolation: <-20 dB @ 700/800 MHz Band, <-17 dB @ 900 MHz Band, <-20 dB @ 1800/1900/2100 MHz Band, <-20 dB @ 2400/2500 MHz Band
5. Polarization: Linear H/V for each radiator
6. Ceiling mounted, white color
7. Dimensions: 220 mm diameter, 50mm height
8. Weight: Not greater than 0.45 kg
9. Impedance: 50 ohms.
10. Maximum Power rating: 50 W
11. Plenum rated pigtail cables.
12. Connectors: two (2) N-type female.

G. DAS In-Building Omnidirectional Tetra Antenna

1. Operating frequency band – 350 to 470 MHz
2. Horizontal beamwidth: 360 degree omnidirectional.
3. Vertical beamwidth: 80 degree
4. Gain: 0 dB
5. Impedance: 50 Ohms
6. VSWR: Less than 1.5:1
7. Maximum Power: 20 Watts
8. Ceiling mounted, white color
9. Dimensions: 180 mm diameter, 40 mm height
10. Weight: Not greater than 0.5 kg.
11. Connector: N-type female.

H. RF Connectors

1. All connectors shall be low Passive intermodulation (PIM) connectors. Typically, this is a gold center conductor with silver-plating on connector. Connectors using dissimilar metal contacts or ferrous materials (e.g., nickel plating) are not allowed. The connector shall use a silver plated body with gold plated inner conductor. Brass bodies and silver or brass inner conductors are also authorized. Examples of such connectors include Times Microwave EZ series, Andrew L4.5 series, and RFS Cablewave LCF series. N-type connectors shall be used.

I. Mobile DAS Monitoring Tool

1. Provide tools and devices to facilitate statistics collection and billing of services based on utilization. The tools shall provide tabulation of data based on actual usage by band by provider by direction (uplink/downlink) by duration by location by date and by time.

J. Grounding and bonding equipment shall meet the specifications outlined in the Division 26 and Division 27 Grounding and Bonding sections.

## 2.5 SPECIAL DISTRIBUTION CABLES

A. LMR 240 Coaxial Cable – Remote Unit to Antenna and POI Connectivity

1. Cable Outside Diameter: 6.10mm (0.24 inch) coaxial helical style.
2. Dielectric type: polyethylene foam
3. Attenuation 17.3 dB/100m @ 450MHz, 42.4 dB/100m @ 2500 MHz.
4. Peak Power: 5.6 KW.
5. Inner conductor solid bare copper (BC).
6. Outer conductor aluminum tape and overall braid tinned copper.
7. Shielding effectiveness: 90dB between two adjacent cables.
8. Bend radius repeated: 63.5mm (2.5 inch).
9. Impedance: 50 Ohm.
10. Low Smoke Zero Halogen (LSZH) jacket.
11. Connector: N-type gender to match application.

B. LMR 300 Cable – POI Connectivity

1. Cable Outside Diameter: 7.62mm (0.3 inch) coaxial helical style.
2. Dielectric type: polyethylene foam
3. Attenuation 13.8dB/100m@450MHz, 34.2 dB/100m @ 2500 MHz..
4. Peak Power: 10 KW.
5. Inner conductor BC.
6. Outer conductor aluminum tape and overall braid tinned copper.
7. Shielding effectiveness: 90dB between two adjacent cables.
8. Bend radius repeated: 76.2mm (3 inch).
9. Impedance: 50 Ohm.
10. Low Smoke Zero Halogen (LSZH) jacket.
11. Connector: N-type gender to match application.

C. LMR 400 Cable – POI Connectivity

1. Cable Outside Diameter: 10.29mm (0.404 inch) coaxial helical style.
2. Dielectric type: polyethylene foam
3. Attenuation 8.9 MHz/100m @ 450 MHz, 22.2 dB/100m @ 2500 MHz.
4. Peak Power: 16 KW.
5. Inner conductor BCCAI.
6. Outer conductor aluminum tape and overall braid tinned copper.
7. Shielding effectiveness: 90dB between two adjacent cables.
8. Bend radius repeated: 101.6mm (4 inch).
9. Impedance: 50 Ohm.
10. Low Smoke Zero Halogen (LSZH) jacket.
11. Connector: N-type gender to match application.

D. WiFi Spare Cable

1. Category 6 UTP 568A terminated

## 2.6 PERFORMANCE REQUIREMENTS

A. General: The performance requirements presented in this section apply to the entire DAS systems unless noted otherwise.

B. All DAS components shall provide wide band, low loss, low PIM, low VSWR and high isolation performance characteristics to maximize overall system efficiency, reduce undesirable RFI emissions and control system energy requirements.

C. System Availability: At any given time, the overall system shall be considered unavailable if any subsystem is not operational, not fully or accurately functional, or does not meet performance criteria for any given system. All systems, subsystems, software, and interfaces shall execute, without degradation, at the scheduled periods and response times for the systems to be considered available.

1. The systems shall operate as specified twenty-four (24) hours per day, seven 7 days per week. Availability of the overall system shall be at least 99.9 % (526 minutes maximum downtime per year).

D. RF levels shall be sufficient to facilitate both-way handovers with the external Mobile and TETRA networks at locations agreed on the target Coverage Area.

E. DAS Carrier Conditioners

1. Integrated Modular rack mounted POI devices shall be provided to improve signaling and optimize network capacity.
2. DAS Carrier Conditioners shall be provided to interface each Mobile Operator Base Station with Mobile DAS head-end equipment and to interface each TETRA Base Station output signals with TETRA DAS head-end equipment.
3. Quantity of devices, frequency bands, inputs and outputs shall match to the application to provide proper Sector assignments, suitable balanced signaling levels and minimize signal losses in accordance with final Mobile Operator and TETRA provider configurations. These modular POI devices shall combine single or multi-band signals, adjust power levels and provide monitoring ports.
4. Where separate uplinks and downlinks are provided by the Base Station equipment, the POI equipment shall maintain separate Tx and Rx connectivity to the DAS head-end equipment.
5. Where Base Station equipment is provided with combined TRx output, the POI equipment shall provide separate Tx and Rx connectivity to the DAS head-end equipment.

## 2.7 NETWORK REQUIREMENTS

A. The system shall utilize the ConRAC LAN to provide system administration, monitoring and alarm communications for head-end master unit, secondary units and remote units.

B. All equipment shall be capable of being SNMP managed, and monitored for centralized administration.

C. The internal proprietary code of the solution may be monitored by a specialized program and not by SNMP. However, this must be coordinated with the requirements of the LAN and approved by the Airport Project Representative.

## 2.8 SYSTEM MONITORING AND MANAGEMENT

A. System administration tools shall include the following capabilities and features:

1. System configuration and control.
2. Web based GUI.
3. SNMP interface for integration into higher level network management systems.
4. Separate user classes and secure communications via SSH/SSL and secure SNMP v3.
5. Event recording and data logging.
6. Web Access.
7. Auto discovery of active system components.
8. Software matrix for flexible assignment of sectors to remote units.
9. Visual status of active equipment.
10. Auto input overload protection.

B. The DAS shall include automatic supervisory and trouble signals for malfunctions of the active equipment including the Primary Units, Secondary Units, and Remote Units. The monitoring shall be by system, with the GSM DAS that provides all 2G/3G/4G LTE and iDEN being monitored. The Tetra DAS is considered a Life Safety System and it is required that alarms be annunciated by the fire alarm system and in compliance with NFPA 72.

C. The DAS System Contractor shall coordinate the integration of the Tetra portion of the DAS with the Fire Alarm System for monitoring as required by the AHJ. The DAS shall be integrated to provide the following indications, normal operation, trouble, and supervisory, for all active equipment on the system:

1. Normal ac power.
2. Trouble.
3. Loss of normal ac power.
4. Equipment Failure
5. Failure of battery charger.
6. Low batter capacity (to alarm at 70% remaining life).

D. The DAS contractor shall coordinate with the fire alarm system provider for a dedicated fire control monitoring panel to be provided within the fire control room and interface to the standard fire alarm panels. The monitoring panel shall provide visual and labeled indication of the following for each signal amplifier:

1. Normal ac power.

2. Signal booster trouble.
3. Loss of normal ac power.
4. Failure of battery charger.
5. Low-battery capacity (to alarm at 70 percent remaining life).

## 2.9 POWER

A. Coordinate all power for all DAS equipment from power panels tied to the Generator backup system to ensure continued operation during commercial power failure. The Tetra DAS shall be powered from the UPS power system to provide continuous operation during a power failure.

B. Coordinate 24 hour auxiliary power back-up system to ensure continued TETRA operation during commercial power failure.

## 2.10 EXPANSION AND SPARES

A. The Contractor shall clearly state limitations of the proposed system in terms of adding additional frequencies capacity, modulation technologies, talk groups and interfaces.

B. At the time of final system acceptance, all hardware shall have a minimum of 13% reserve capacity, with the capability to further increase the capacity by 50% with no change to the system design.

C. The system shall be designed such that expanding the Mobile and TETRA Radio coverage shall not have a negative impact on the system. For example, adding a specific TETRA rental car operator frequency to the system shall have no impact on the overall system design or performance.

D. The assignment of remote units to secondary units shall be interleaved to allow failure of any secondary unit to have minimum impact to the overall coverage area. This shall be accomplished by connecting adjacent sequential remote units to different secondary units. However, final connection shall ensure that all mobile handover zones have clear demarcation and are not crisscrossed within same physical zone.

E. The Contractor shall provide minimum 3% spare equipment or minimum of one unit, whichever larger, for all remote units, secondary units, and modular head-end components, including coaxial cables patch cords of usable length for each type.

F. The Contractor shall provide two standby pre-configured and pre-cabled primary head-end units with patch panels to provide ready replacement of any failed primary head-end unit. One standby unit shall be pre-configured for TETRA and one standby unit shall be preconfigured for Mobile.

## 2.11 HEALTH AND SAFETY

A. Appropriate exposure limits for Human exposure to electromagnetic fields (EMF) will be in compliance with the levels defined by International Commission of Non-Ionizing Radiation Protection (ICNIRP) standard.

B. All antennas deployed must radiate EiRP less than 20 dBm or as approved by AHJ.

C. Under Construction Design Manufacture regulations the Design Contractor is obliged to document any risks, hazards or material health and safety issues in the proposed design(s).

1. Berrylium Oxide is used in many devices such as load resistors and some other components incorporated into RF products. In a solid form, this substance presents no special risk, but in the form of airborne particulates, it is an extremely dangerous substance, which is registered as a potential carcinogen. The effects of opening or incinerating these devices could release material with which contact could be fatal. Overexposure to airborne beryllium particulates may cause a serious lung disease called chronic beryllium disease (chronic beryllosis). As long as items marked with a beryllium warning label are not disturbed, there is no significant risk. Later disposal of such items should be by return to the source equipment supplier for safe disposal.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Contractor shall ensure adequate environmental conditions, communications infrastructure, Service Provider services, electrical power, grounding, physical security, access and other requirements are provided as necessary before installation of Data Communications systems.

B. The Contractor shall coordinate and submit plans and equipment components for approval by the AHJ, prior to installation. A renewable permit for the public safety radio enhancement shall be obtained where required by the AHJ.

## 3.2 INSTALLATION

A. Install components in accordance with contract drawings, manufacturer’s guidelines and installation instructions, and approved submittal data.

B. System installation and construction methods shall conform to NFPA 72.

C. Lightning /Surge Suppression Devices:

1. All exterior or exposed mounted antennas shall be fitted with lightning protectors (arrestors). Each lightning suppression device shall have its own home run ground cable.

2. All RF cables shall be grounded in accordance with the manufacturer's recommendations and applicable standards. Contractor shall provide grounding kits to ground RF cabling at both ends and along length of cable as required.

D. Contractor shall coordinate antenna mountings and final locations with the interior designer where devices are exposed to public view.

E. Provide the following:

1. System layout with fiber optic link budget calculations.
2. RF Spectrum Analysis to identify sources of wireless interference, generation of spurious emissions or rebroadcast of unauthorized frequencies.
3. Mitigation of wireless interference affecting DAS functionality and generation of interference affecting other systems.
4. Testing to optimize in-building antenna locations and quantities necessary to provide the required usable signal coverage. Tests shall be conducted for 4G LTE and TETRA at least 1000 locations with at least 5 tests per location throughout the project boundaries to be submitted for approval in advance
5. Coordination with Construction Manager and Architect prior to ceiling construction for any revised or additional in-building antenna locations and mountings.
6. Inter-modulation study and confirmation no DAS system desensitization, oscillation, spurious emissions and no rebroadcast of unauthorized frequencies are present.
7. Coordination, verification of system operation and testing by each Mobile Operator and TETRA Radio provider.
8. Rebroadcast approval from each of up to four (4) Mobile Operators and three (3) TETRA Radio providers: The KAIA Airport, the Ministry of the Interior (MOI) and Saudi Airlines.

F. Where undefined by codes and standards, Contractor shall apply a safety factor of at least two (2) times the rated load to all fastenings and supports of system components.

G. Contractor shall perform physical installation of all system components including furnished equipment, and appurtenances in accordance with the manufacturer's instructions, and shall furnish all cables, connectors, terminators, interconnections, mountings, conduit, supports, hangers, penetrations, sleeves, firestopping, services, and adjustments required for a complete and operable system.

H. Certain telecommunication pathways are provided on the drawings for use by DAS cabling. The Contractor shall be responsible for providing all conduit and cabling to any secondary units, remote units, and antennas that are required, but are not currently provided for.

1. Coaxial cable shall be provided between each antenna and the remote unit. Coaxial cable shall be continuously supported, or at intervals of no more than one (1) meter. The Contractor shall make note of ceiling conditions and provide means (conduit) to support cable over inaccessible ceilings.
2. Category 6 UTP cable shall be provided between each Data Room and each antenna for use by WiFi contractor.

3. Use the provided one tight buffer single mode fiber cable within 25mm (Trade size 1) conduit as a home run from each remote unit to the secondary unit per the Drawing Schedules, using minimum 6 core for Mobile DAS or one minimum 4 core for TETRA DAS and in compliance with maximum passive link loss requirements.
4. Where sufficient ISP or OSP fiber cores are not available, coordinate provision of additional single mode fiber connectivity from the secondary unit to the primary head-end master unit in compliance with maximum passive link loss requirements. Where additional fiber cables are required, provide standard fiber cable core quantities to include minimum 25% spare cores. ISP and/or OSP cabling may be required.

I. Permanent external filters shall not be permitted.

J. In-building communication cable tray provided under other Sections may be utilized for fiber cabling, but shall not be utilized for DAS coaxial cable.

K. Apply the latest patches and security updates. Register system equipment with the manufacturer under the Employer's name.

L. System grounding shall be installed per applicable standards and as necessary to preclude ground loops, noise, and surges from adversely affecting system operation.

M. All system components shall be clearly labeled following ANSI/TIA 606-B nomenclature.

## 3.3 DOCUMENTATION

A. System Administrator Documentation: The Contractor shall supply three (3) hardcopies of administrator documentation and three (3) copies of the documentation in PDF format on CD-ROM that detail the operation of the system. This documentation shall provide complete information on the configuration, business rules, operation, maintenance, and trouble-shooting of the system.

## 3.4 GENERAL TESTING REQUIREMENTS

A. The contractor shall develop and execute an onsite Customer Acceptance Plan in compliance with manufacturer requirements and guidelines to include:

1. Complete testing to document compliance with all performance parameters and requirements.
2. Use of a grid cell system to confirm Mobile and TETRA usable signal coverage, as more fully described in NFPA 72, for testing within buildings.
3. Downlink testing shall include:

    a. Calibrated spectrum analyzer or calibrated automatic signal level measurement recording system to measure signal strength in dBm.

b. Receiving antennas of equal gain to the agency's standard portable radio antenna, oriented vertically, with a centerline between 0.91 m and 1.22 m above floor.
c. Resolution bandwidth nearest the bandwidth of the channel under test.
d. Levels recorded while walking an "X" pattern, with the center of the pattern located approximately in the center of each grid area.
e. Linear distance of each side of the "X" equal to at least 10 percent of the length of the grid's side and a minimum length of 3.0 m.
f. Measurement sampled in averaging mode to include a minimum of one sample per each 1.52 m traveled, recorded with not less than five samples per measurement recorded per side of the "X".

4. A spectrum analyzer shall be utilized to ensure spurious oscillations are not being generated or unauthorized carriers are being repeated in violation of regulations.
5. Measurements shall be analyzed for correct gains on both unlink and downlink paths, noise floor elevation from active components, intermodulation, and other parameters determined necessary by the AHJ.
6. Backup batteries and power supplies shall be tested under load for a period of 1 hour to verify that they will properly operate during an actual power outage.
7. Testing of both uplink and downlink signal performance.
8. All manufacture recommended systems testing.
9. Verification of overall Mobile and TETRA DAS operation.
10. Obtain each Mobile Operator and TETRA provider verification of proper system operation by requesting each Mobile Operator and TETRA provider to conduct a test on the system and certify that the coverage is acceptable.
11. Record all test procedures and results.
12. Record in tabular form all test results, deficiencies, and corrective measures.

B. The plan shall address all requirements identified in this specification and test all contractor supplied cabling and hardware components. The plan shall follow accepted industry testing practices, NFPA 72 and have a method of independent verification described.

C. Any specified item that does not satisfy the requirements of this specification or the AHJ shall be replaced, upgraded, or added by the contractor as necessary to correct the noted deficiencies. After correction of a noted deficiency, re-testing shall be performed to verify the effectiveness of the corrective action.

## 3.5 TRAINING

A. Contractor shall provide any training necessary for use, administer and/or maintenance of the in-building distribution system. Contractor is to coordinate with the Employer on time and place for training. Training sessions are to accommodate personnel schedules. Training shall include familiarization with radio equipment settings and configuration

END OF SECTION 275300

# SECTION 28 23 00 – VIDEO MANAGEMENT SYSTEM

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Contractor shall include in the bid all labor, materials, tools, plant, transportation, storage costs, training, equipment, insurance, temporary protection, permits, inspections, taxes and all necessary and related items required to provide complete and operational systems shown and described in the Specifications.

B. The Contractor is responsible for providing and coordinating final equipment arrangements, locations, phased activities and construction methods that minimize disruption to operations and provide complete and operational systems.

C. The Contractor shall coordinate work of this Section and other Division 27 and 28 Sections with specialty electronic, CCTV, ACS, Information Technology (IT) Data Networks, Audio Visual systems and displays, any other IT infrastructure dependent systems vendors or installation contractors from these other Sections.

D. Related documents:
   1. Division 00 and 01 Sections
   2. Division 26 Sections
   3. Division 27 Sections
   4. Other Division 28 sections

### 1.2 SCOPE OVERVIEW

A. The main function of this project is to add video coverage at all areas shown on Construction Drawings and provide a central video storage facility on a separate security network. The contractor is responsible for all activities, and the supply installation and commissioning of all components and systems to achieve this.

### 1.3 SUBMITTALS

A. Comply with all Submittal Procedures. The following is in addition to or complementary to any requirements given in those Sections or elsewhere.

B. Submit calibration reports for all test equipment, the calibration shall be performed by a manufacturer certified calibration facility and be dated no more than sixty (60) days prior to the start of testing.

C. Project Record Documents required include:
   1. Marked-up copies of Contract Drawings
   2. Marked-up copies of Shop Drawings
   3. Newly prepared Drawings
   4. Marked-up copies of Specifications, Addenda and Change Orders

5. Marked-up Project Data submittals
6. Record Samples
7. Field records for variable and concealed conditions
8. Record information on Work that is recorded only schematically
9. As-built drawings
10. Record drawings
11. Electronic as-built and GIS requirements

D. Post changes and modifications to the Documents as they occur. Drawings will be updated electronically and submitted to Design professional in accordance with the schedule provided for this by Design professional. Do not wait until the end of the Project. Design Professional will periodically review Project Record Documents to assure compliance with this requirement.

E. At every quarter, submit Project Record Documents to Design Professional for Owner's records.
1. Upon completion of the as built drawings, the Design Professional will review the as built work with the Contractor.
2. If the as built work is not complete, the Contractor will be so advised and shall complete the work as required.

F. Project Record Drawings shall also be submitted in electronic format. Electronic drawing format shall be AutoCAD® Release 2014 unless otherwise noted. Design professional shall have the right and capability to manipulate all electronic file drawings and documentation.

## 1.4 CODES, STANDARDS AND REFERENCES

A. In addition to references given in Section 01 88 00 all work and materials shall conform to and be installed, inspected and tested in accordance with the governing rules and regulations of the telecommunications industry, as well as federal, state and local governmental agencies, including, but not limited to the following:
1. ANSI B20.1 Conveyor Safety
2. ASTM F.1468-93 Standard Practice For Evaluation
3. Customs and Border Protection Airport Technical Design Standards for Passenger Processing Facilities, August 2006
4. EIA 232-D Interface between Data Terminal Equipment and Data Circuit-Termination Equipment Serial Binary Data
5. EIA RS-310-C Racks, Panel, and Associated Equipment
6. 49 CFR 1520 Protection of Sensitive Security Information
7. 49 CFR 1540 Civil Aviation Security General Requirements
8. 49 CFR 1542 Airport Security
9. 49 CFR 1544 Aircraft Operator Security
10. 49 CFR 1546 Foreign Air Carrier Security
11. 49 CFR 1548 Indirect Air Carrier Security. NFPA 72-D - Installations, Maintenance and Use of Proprietary Protective Signaling Systems
12. NFPA 75 Protection of Electronic Computer Data Processing Equipment
13. NFPA 77 Static Electricity
14. NFPA 78 Lightning Protection Code
15. Transportation Security Administration Recommended Security Guidelines for Airport Planning, Design and Construction, June 15, 2006
16. UL 294 Access Control System Units

17. UL 611 Central Station Burglar Alarm Units and Systems
18. UL 634 Intrusion Detection Units
19. UL 681 Installation and Classification of Mercantile and Bank Burglar Alarm Units
20. UL 796 Electrical Printed-Wiring Boards
21. UL 1076 Proprietary Burglar Alarm Units and Systems
22. UL 1950 Information Technology Equipment, including Electrical Business Equipment References to codes and standards called for in the Specifications refer to the latest edition, amendments, and revisions to the codes and standards in effect on the date of these Specifications.
23. RTCA 230B Integrated Security System Standards for airport Access Control
24. Owner Technical Infrastructure Design and Construction Guidelines: Kansas City International Airport Rev 0

B. References to codes and standards called for in the Specifications refer to the latest edition, amendments, and revisions to the codes and standards in effect on the date of these Specifications.

## 1.5 QUALITY ASSURANCE

A. The Contractor shall have at least on-site superintendant on each shift that is trained and certified by the vendor of the proposed System to be an installer of that System. The Contractor shall offer proof of certification by submitting a copy of the certification with the Bid. The Contractors qualified staff shall be part of the Contractors team throughout the duration of the project to assist on shop drawings and other related technical issues.

B. The Contractor’s Quality Assurance Inspector shall conduct a visual inspection of all installations to verify that the installations are in accordance with these specifications and the manufacturer's specifications. Records of the inspections signed and dated by the Quality Assurance Inspector shall be provided to the Design Professional. The Design Professional shall be notified by the Contractor of any inspection(s) and the Design Professional may elect to participate in any inspection(s).

## 1.6 SUBSTITUTION OF EQUIPMENT and SOFTWARE

A. Approval of alternate or substitute equipment or material or software in no way voids Specification requirements.

B. Under no circumstances shall the Design professional be required to prove that an item proposed for substitution is not equal to the specified item. It shall be mandatory that the Contractor submits to Design Professional all evidence to support the contention that the item proposed for substitution is equal to the specified item. The Owner’s decision as to the equality of substitution shall be final and without further recourse.

C. In the event that the Design Professional is required to provide additional engineering services as a result of substitution of equivalent materials or equipment by the Contractor, or changes by the Contractor in dimension, weight, power requirements, etc., of the equipment and accessories furnished, or if the Design Professional is required to examine and evaluate any changes proposed by the Contractor for the convenience of the Contractor, then the Design Professional’s expenses in connection with such additional services shall be paid by the Contractor and may be deducted from any moneys owed to the Contractor.

## 1.7 EQUIPMENT CERTIFICATION

A. Provide materials that meet the following minimum requirements:

1. Electrical equipment and systems shall meet UL Standards (or equivalent) and requirements of the NEC. This listing requirement applies to the entire assembly. Any modifications to equipment to suit the intent of the specifications shall be performed in accordance with these requirements.

2. Equipment shall meet all applicable FCC Regulations.

3. All materials, unless otherwise specified, shall be new and be the standard products of the manufacturer. Used equipment or damaged material is not acceptable and will be rejected.

4. The listing of a manufacturer as “acceptable” does not indicate acceptance of a standard or catalogued item of equipment. All equipment and systems must conform to the Specifications.

5. Where applicable, all materials and equipment shall bear the label and listing of Underwriters Laboratory or Factory Mutual. Application and installation of all equipment and materials shall be in accordance with such labeling and listing.

B. Manufacturers of equipment assemblies that include components made by others shall assume complete responsibility for the final assembled unit.

1. All components of an assembled unit need not be products of the same manufacturer.
2. Constituent parts, which are alike, shall be from a single manufacturer.
3. Components shall be compatible with each other and with the total assembly for intended service.
4. The Contractor shall guarantee for a minimum of five (5) years, the performance of assemblies of components, and shall repair or replace elements of the assemblies as required to deliver specified performance of the complete assembly.

C. Components of equipment shall bear the manufacturer's name or trademark, model number and serial number on a nameplate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment.

D. Major items of equipment that serve the same function must be the same make and model.

E. Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that a complete and fully operational system will result.

F. Maximum standardization of components shall be provided to reduce spare part requirements.

## 1.8 WARRANTY

A. Materials and workmanship shall meet or exceed industry standards and be fully guaranteed.

1. All labor must be thoroughly competent and skilled, and all work shall be executed in strict accordance with the best practice of the trades.

2. The Contractor shall be responsible for and make good, without expense to Owner, any and all defects arising during this warranty period that are due to imperfect materials, appliances, improper installation or poor workmanship.

B. Software Licenses:

1. Commercial software packages shall have all registration and licensing documentation filed indicating Owner as the owner of the software. Costs for commercial off-the-shelf software licenses shall be included. Licenses shall be perpetual and require no annual or similar payment.
2. Software developed for this proposal shall be licensed in perpetuity to Owner. This license shall include all executable, library, object, and source code required to maintain and modify the delivered product. Where possible this information shall be delivered on CD-ROM. All compilers, case tools, utilities, etc. that are needed to create executable code shall be included.
3. All software version upgrades available, bug fixes, patches etc required for either proprietary or COTS software during the one year warranty period shall be installed and provided on CD ROM as part of the base price proposal.

## 1.9 ON-SITE PERSONNEL REQUIREMENTS

A. Installation and testing crews shall have completed all appropriate training in professional installation as required by the manufacturer.

B. The Contractor shall obtain the approval of Design Professional for the final layout of equipment to be installed in telecommunications rooms prior to the installation of any materials or equipment. Shop drawings showing proposed room layouts shall be submitted for approval before beginning installation.

C. The Contractor shall furnish an adequate supply of technicians and materials at all times, and shall perform the work in the most appropriate, expeditious, and economical manner consistent with the interests of the Owner.

D. The Contractor shall be responsible to Owner for the acts and omissions of its employees, subcontractors and their agents and employees, and other persons performing any of the work under a contract with the Contractor.

E. The Contractor shall not unreasonably encumber the site with any material or equipment. Operations shall be confined to areas permitted by law, permits, and contract documents.

F. The Contractor shall have an experienced English speaking Project Manager, with prior experience of the VMS supplier selected on site at all times when work is in progress on any project. The individual who represents the Contractor shall be the single point of contact between the Contractor and Owner, and shall be responsible for the entire project. This representative shall be able to communicate with Owner or designated representative whenever requested throughout the life of the project.

G. While working in the facility, the Contractor shall not block any entrances, egresses, or other passageways that are necessary for normal, safe operation. It should be noted that the Contractor is responsible to provide any lifts, hand trucks, etc. that it will need to transport its materials and equipment and install system components throughout the site.

H. The Contractor shall protect all buildings, walls, floors, and property from damage resulting from the installation. Any and all damage to property shall be repaired by the Contractor at its expense. If the Contractor enters an area that has damage (not caused by the Contractor), the Contractor shall immediately bring this to the attention of the Design Professional so the area can be appropriately noted.

I. Following each day's of shift's work, the Contractor shall clean up the areas in which it has been working and dump all trash in the appropriate designated areas.

## PART 2 - PRODUCTS

### 2.1 OVERVIEW OF SYSTEM

A. Nature
   1. The purpose of the system is to provide a complete and single video management system at ConRAC excluding those provided by tenants. This video system will use IP technology.

B. Function
   1. The system shall provide a single GUI format via which all video functions can be managed. These functions are listed below in section 2.3

C. Distribution

   1. The system shall consist of three types of components:
      a. Video cameras
      b. Storage and video servers to be installed in the terminal and police data center respectively
      c. Workstations to access and control the system

D. Camera complement

   1. The system shall consist of around 200 new cameras.

### 2.2 SYSTEM PERFORMANCE RQUIREMENTS

A. Availability
   1. The system as a whole shall be available 99.99%

B. Capacity
   1. The capacity of the system as installed shall be for 1200 cameras, with a video storage capability online 60 days of video at the equivalent of 4CIF 15 FPS for all cameras and unlimited archive capability

C. Scalability
   1. Expandable to 4000 cameras and a video storage capability of 180 days and unlimited archive capability

D. Management

1. The system shall be capable of being managed via one GUI from a single workstation. This management will cover all components of the system without exception.

E. User interface

1. The user interface shall be similar to the management interface but will provide user control and operational capabilities of all cameras and functions from a single GUI.

F Failover

1. The system shall failover from its primary severs to the backup servers and be fully operational on the secondary servers within 15 seconds and not require any operator action

G Failback

2. The system shall revert back to the primary servers within 15 seconds of being so requested by a system administrator

## 2.3 SOFTWARE FUNCTIONALITY

A. Live video viewing

1. The system shall allow the viewing of live video from any camera on the system at the highest rate of resolution and frame rate that the camera will support on any workstation on the network. Up to 250 live views may be requested at any one time.

B. Recorded video viewing

1. The system shall allow the viewing of recorded video from any camera on the system at whatever rate the camera was recorded. Up to 250 such views over the entire network may be requested at any one time.

C. Storage of video

1. The system shall store on line at two separate locations 60 days of video at the equivalent of 4CIF 15 FPS for all cameras
2. The system shall provide the capability to manage the video storage to allow selective deletions, backups, and auto aging.
3. The system shall provide the capability to store video according to different parameters at each of the two server sites.

D. Archiving of video

1. The system shall provide the offloading of video onto tape from one of the storage locations. The system shall provide for the unlimited storage of video by this means.

E. User interface Requirements

1. The user interface shall be a GUI and shall confirm to standard windows protocols and allow the control of all functions via a simple easy to use interface.

F. User management requirements

1. The system shall provide a layered level of user access control over the system functions from basic user to system administrator. This level of control shall be possible by function, specific camera, geographic location, subsets of cameras or time zone, or any combination thereof.

G. Functional Requirements

1. The VMS system will provide a comprehensive set of capabilities to store control and manage video from at least 1000 cameras
2. It will provide the capability to select duration and resolution of storage by camera, time and activity event and user request. It will provide the capability to control the access to video by camera, user, and time.
3. It will allow access to recorded video subject to similar constraints and will automatically provide event and bookmark tag information and allow retrospective analysis of past video by simple analytics including motion detection in an area.
4. The system shall automatically off load data to archive media and shall index such data and allow for simple recovery of specific periods of video
5. The system will allow the linkage between the ACS data base and the VMS data base so that for example, video clips of all access at a specific door can be requested, or all accesses by a specific person at doors. In both cases this capability is required only for doors with associated video coverage.
6. Video clips of specific events shall be capable of being separately stored and offloaded to CD together with any associated meta data for subsequent independent playback.
7. The System shall provide the capability to digitally sign recorded video using 248-bit RSA public/private key cryptography or approved equivalent

H. GUI Requirements
1. The user interface shall be via a GUI providing multiple video streams simultaneously on multiple monitors.
2. This GUI shall be configurable per operator and shall allow each operator to dynamically select and display and video permitted to that operator, subject to screen availability.
3. The system shall have the capability to store and record operator specific options, such as screen layout, video layout, action on alarm, “video salvo” on events.
4. The GUI shall conform to standard Windows conventions.

I. GUI for system administration
1. This shall be similar to that provided for the user and shall use common terminology etc.
2. The GUI shall conform to standard Windows conventions

J. MAP requirements
1. The system shall support a mode of operation whereby a map of all or part of the airport ( at operator request) is displayed on a separate or local screen and that status information can be used via an icon access to any cameras on that part of the airport will be accessible by means of an icon on that screen.
2. These MAPS shall be defined so that an operator may make a selection from library of which Map he/she needs, and it will be displayed within ten seconds.

K. Reporting requirements
1. The system shall provide a full reporting capability for all its functions and data bases and logs allowing an appropriately privileged user access to all and any records in a reasonable time period.

L. Unified camera control
1. The system shall provide unified GUI camera control at an operator's workstation for all types of cameras installed in ConRAC whether existing or new. By means of this unified control the following functions shall be provided
   a. PTZ

b. Setup and adjustment
c. Determination of presets
d. Any other commissioning and camera setup activity

2. If the system proposed by the contractor cannot achieve this unified control, the contractor shall replace any cameras communication devices and infrastructure as required to support this capability at no extra cost.

M. Manufacturers

1. The following manufacturers of video management systems are acceptable
   a. Nice
   b. Genetec

## 2.4 SOFTWARE REQUIREMENTS

A. Operating systems
1. The system shall use the Windows operating systems version 10

B. Data base
1. The system shall use the Oracle data base systems version 11 with latest updates

C. Management
1. The management of the system shall conform to the Owner IT standards

D. Update management
1. The update management of the system shall conform to the Owner IT standards.

E. Virus protection
1. The virus protection of the system shall conform to the Owner IT standards.
2. All software, firmware etc shall be virus scanned before introduction on any system, processor or panel on the Security network.

F. Security
1. The security policies and practices of the system shall conform to the Owner standards. Owner utilizes standard Microsoft technology for its password and domain structure

G. Video input support
1. The system shall support all methods of video encoding including H.264, MPEG and Motion Jpeg at all levels of resolution and frame rate.

H. Audio input support
1. The system shall support audio recording as required in association with video recording
2. The system shall support separate or synchronous playback.

I. Video Analytics
1. The system shall support video analytics at selected camera and/or encoder and/or server level.
2. These analytics will include:
   a. Motion detection
   b. Vehicle plate recognition

3. The analytics shall be capable of being used retrospectively.
4. The analytics for a and b above shall not be required at more than 10 cameras each.
5. Analytics may be provided by third party plug in modules subject to approval of the Design professional.

J. Reconfiguration and SDK capabilities
1. The system shall allow reconfiguration by users without recourse to special languages.
2. A system SDKs shall be supplied with all required supporting software to allow the integration of the system with new devices and other systems

## 2.5 SERVERS

A. The exact nature and number of the servers shall be determined by the contractor consequent on its selection of a specific VMS supplier. The contractor is responsible for providing as many servers as is required by their final design to support the functionality described in these specifications. All servers shall be of the same type and manufacturer and have similar configuration, only variable by network and fiber channel interfacing requirements.

B. Notwithstanding the following requirements shall apply:

C. Performance
- CPU Processor: Intel Core 2 Duo, 3.33Ghz, 6M, 1333Mhz FSB
- RAM: 8 GB DDR2 SDRAM, 800Mhz
- Internal Hard Drive: 500GB, 7,200 RPM, 2.5" SATA, 3.0Gb/s, 16MB Cache

D. Software
1. The servers shall utilize:
   a. Operating system: Windows 10
   b. Servers Windows 2013
   c. Data base Oracle version 11 with latest updates
2. Manufacturers
   a. Servers:
      1) HP Proliant G6 series,
      2) Dell PowerEdge servers
      3) IBM

E. Performance and capacity
1. The servers shall be configures with memory and processors to ensure that the system as a whole maintain its required performance in all aspects. Servers shall be provided at each of the locations for all functions unless so otherwise explicitly specified.

F. UPS

All servers shall be powered by the UPS in telecom room in which they are located

G. Local Monitor

Each rack of servers will have available a local monitor connected to the various severs in that rack, by a KVM switch for maintenance and operational support. The unit will have an integrated screen and keyboard, will support up to 16 servers, and have a screen dimension of 19inches diagonal.

Manufacturer:

Tripp Lite.

H. Connectivity
1. The servers shall be connected to the network by means of redundant 1000Base Network cards and to the storage system by redundant fiber channel links.

I. Failover
1. The servers shall be configured to failover between the redundant servers such that the total period the system is not available and fully operative shall be 15 seconds or less.
2. Solutions using Microsoft cluster technology do not meet this requirement and are thus not acceptable.

J. Failback
1. The servers shall be configured to failback between the redundant servers such that the total period the system is not available and fully operative shall be 15 seconds or less.

## 2.6 VMS WORKSTATIONS

A. The exact nature and number of the workstations shall be determined by the contractor consequent on its selection of a specific VMS supplier. The contractor is responsible for providing as many workstations as is required by their final design to support the functionality described in these specifications.

B. All workstations shall be of the same type and manufacturer and have similar configuration, only variable by network and location requirements. Notwithstanding, the following requirements shall apply:

C. Software
1. The workstations shall utilize:
a. Operating system: Windows 10
b. Servers Windows 2013
c. Data base Oracle version 11 with latest updates

D. Performance
1. The workstations shall be provided with enough memory and graphics card capability to support at least 16 full motion video streams per workstation with no delay in retrieval and smooth non delayed, jitter free video presentation with the video management system selected.
2. Notwithstanding the above each workstation shall be provided with at least the following configuration:
3. Performance and Storage
- CPU Processor: Intel Core 2 Duo, 3.33Ghz, 6M, 1333Mhz FSB
- RAM: 4 GB DDR2 SDRAM, 800Mhz
- Hard Drive: 250GB, 7,200 RPM, 2.5" SATA, 3.0Gb/s, 16MB Cache
- Peripherals: 16X DVD+/-RW SATA

4. Video

256MB, Dual DVI

5. Network Ports
   10/100/1000BaseT Ethernet RJ-45
6. USB ports
   - Keyboard and Mouse DIN
   - Audio mini

E. Video output
1. The workstations shall support at least two graphics screens at full resolution.

F. Connectivity
1. The workstations shall be connected to the network by 1000BaseT links.

G. UPS

All workstations shall be powered by the UPS in telecom room or control center in which they are located.

H. Manufacturers
1. HP
2. Dell
3. IBM

2.7 Video wall display workstation/servers

A. There shall be at least 10 of these and the video displays.

B. The VMS display workstations/servers shall have device drivers capable of driving the video wall displays at all times at 1920x1080.

C. Performance
1. The processors for these displays shall be provided with enough memory and graphics card capability to support at least 16 full motion video streams per workstation with no delay in retrieval and smooth non-delayed, jitter free video presentation.
2. Notwithstanding the above each processor shall be provided with at least the following configuration:
3. Performance and Storage
   - CPU Processor: Intel Core 2 Duo, 3.33Ghz, 6M, 1333Mhz FSB
   - RAM: 4 GB DDR2 SDRAM, 800Mhz
   - Hard Drive: 250GB, 7,200 RPM, 2.5" SATA, 3.0Gb/s, 16MB Cache
   - Peripherals: 16X DVD+/-RW SATA
4. Video
   256MB, Dual DVI
5. Network Ports
   10/100/1000BaseT Ethernet RJ-45
6. USB ports
   - Keyboard and Mouse DIN
   - Audio mini

D. UPS

All such display servers/workstations shall be powered by the UPS in telecom room in which they are located

E. Connectivity

The workstations shall be connected to the network by at least 1000 BaseT links

F. GUI and remote access.

These display workstation/servers (ten, corresponding to the 10 screens on the video wall) shall be controlled by a GUI similar to that of the conventional VMS workstation. Access to this GUI will either be via remote console connection at the ACC workstation, or for maintenance and administrator functions at the KVM monitor at the rack in the data center in which they are located. Full access to all VMs functions shall be available via these workstation/servers. Use of the rack KVM monitor screen and remote console connection shall be in addition to the video output to the video.

2.8 Workstation displays

A. These shall be attached to each workstation by a dual video driver. Each screen shall be at least 24 inches diagonal shall have device driver capable of driving these displays at all times at 1920x1080

B. The overhaul base workstation shall only have one screen

C. Manufacturers:

Dell

Hewlett Packard

2.9 PRINTERS

A. All printers shall be connected to the UPD in the telecommunication room or control center in which they are located.

B. Report printers

Black and white printers capable of 600dpi resolution and 30ppm

C. Video image printers

Color prints capable of 600dpi resolution and 10 ppm

D. Manufacturers

Hewlett Packard

## 2.10 VIDEO DATA STORAGE

A. The exact nature and number of the video storage shall be determined by the contractor consequent on its selection of a specific VMS supplier. The contractor is responsible for providing as many video storage units as is required by their final design to support the functionality described in these specifications. All video storage units shall be of the same type and manufacturer and have similar configuration, only variable by network and fiber channel interfacing requirements. Notwithstanding, the following requirements shall apply:

B. Locations
   1. The locations available for video storage are:
      a. The MPOE in Building A
      b. IT Room in Building E

C. Capacity
   1. The capacity of the storage units shall be to store 60 days of video at the equivalent of 4CIF 15 FPS for all cameras at each of the two redundant locations

D. Performance and reliability
   1. The systems provided shall provide at least 99.999 % availability and protection at RAID level 6.
   2. The system shall provide the capacity to ensure that retrieved video is available at a workstation within one seconds of identification for live video and five seconds for archived but not offloaded video.
   3. The system shall support up to 24 workstations requesting such video data simultaneously.

E. Storage Area Network
   1. The system shall interface to the IP network to allow monitoring and management but shall use fiber channel for attachment to video servers independent of the network. This storage area network shall have dual links to each server or archive unit capable of operating at 4GBps

F. Network connectivity
   1. Will be available to each unit to allow for remote management

G. UPS

   All servers shall be powered by the UPS in the telecommunication rooms in which they are located.

H. User interface
   1. A GUI shall be available for the management of the storage, and storage area network

I. Recovery
   1. The system shall provide at least RAID 6 data protection and recovery

J. Failover
   1. The system shall provide failover from one storage unit to another within 15 seconds

K. Manufacturers
   1. Acceptable Manufacturers:
   2. Fiber channel switch:

a. Q logic
b. IBM
c. DELL
d. Brocade

3. RAID:
a. Dell
b. IBM
c. Promise

## 2.11 VIDEO ARCHIVE STORAGE

A. Description

The purpose of this component is to allow the occasional offloading of video for archival storage onto off-loadable media for long terms storage (potentially several years). The system shall use digital tape technology, and provide a complete tape and data labeling, data quality control and management system

B. Locations
1. The video archive storage shall be installed at the following locations
a. MPOE Building A
b. IT Room Building E

C. Capacity
1. The system shall provide for the ability to offload video and associated meta data to tape storage.

D. Performance
1. The system shall be such that one Tera-byte of video can be backed up within half an hour
2. Each tape units shall have at least two drives.

E. UPS

All tape units shall be powered by the UPS in the telecommunication rooms in which they are located.

F. Network and SAN connectivity
1. The tape unit(s) shall be attached to the network for management purposes but shall be directly attached to the storage area network such that archival data transfers between the video storage and the archive video storage are not on the network, but on the storage area network only.

G. Self testing and recovery
1. The system shall have self test capabilities so as to verify the readability of tapes stored by means of a test cycle program. If tapes do become corrupted, the system shall provide for recovery of non corrupted sections of the tape and not require abandonment of the entire tape.

H. User interface
1. The user interface shall be by means of a GUI, and/or via CLI and scripts for automated archiving selectable by the user.

I. Manufacturers
1. IBM

2. DELL
3. HP

J. Software

Symantec backup.

## 2.12 SOFTWARE AND DATA BASE BACKUP

A. Description
1. The purpose of this function is providing a capability to back up all the software configuration tables and data base (non video) to allow reconfiguration and recovery as required.
2. In addition it shall also provide the capability to image servers so as to allow fast recovery without software rebuild in the event of hardware or sever software failure

B. Hardware
1. The system shall provide an off-loadable media to allow the data to be remotely stored. This media shall either be digital tape or CD or a combination thereof
2. This capability shall be provided at both server locations.
3. The unit shall be powered by the UPS in the telecommunications room in which it is located.

C. Performance
1. The system shall allow any of the software/data for any server/ workstation etc to be operational within 15 minutes of request and media available

D. Suppliers
1. For imaging
a. Norton ghost
b. or approved equal

## 2.13 NETWORK UTILIZATION

A. Over view of use of network
1. The network is described in detail in section 27 21 00.
2. The VMS system shall use this network for all functions save the connection of the camera to the network or via FOT devices to an encoder, which shall use dedicated connections, which notwithstanding shall conform to Specification Sections 27 and 28.
3. The VMS shall be separated from other systems by means of VLANs. The setup of this network shall be submitted to the Design professional prior to implementation

B. Permitted protocols
1. All protocols used shall either be industry of regulated standard protocols. No manufacturer specific protocols shall be used except with the prior approval of the Design professional. The list of proposed protocols shall be submitted for approval with product submittals.

C. QOS
1. The system shall provide appropriate separation between video streams such that a uniform QOS is maintained between servers, users and live and recorded video

D. Security
   1. The system shall detect if any intruders of any type attempt to intercept video, and intruders attempt to insert video and any intruders attempt to spoof video both in the network and at the devices.
   2. The mechanisms and protocols by which this is to be achieved shall be included in the product submittals for review and approval by the Design professional

E. Management
   1. The system shall be compatible with the Owner network management systems

## PART 3 - EXECUTION

### 3.1 GENERAL

A. System installation and construction methods shall conform to Owner requirements, requirements of the State of California and all applicable building codes.

B. Contractor shall install equipment to meet Seismic Zone 1 requirements of the State of California as stated herein. Where undefined by codes and standards, Contractor shall apply a safety factor of at least 2 times the rated load to all fastenings and supports of system components.

C. Before construction work commences, the Contractor shall visit the site and identify the exact routing for all horizontal and backbone pathways.

D. All equipment locations shall be coordinated with other trades and existing conditions. Coordinate work with other trades and existing conditions to verify exact routing of all cable tray, conduit, etc. before installation. Coordinate with all the Telecommunications, Mechanical, Baggage Handling and Electrical Drawings. Verify with Design Professional the exact location and mounting height of all equipment in finished areas, such as equipment racks and telecommunications devices.

### 3.2 INSPECTIONS

A. The Contractor shall perform a detailed inspection of the site prior to submitting any technical data for approval.

B. The Contractor shall verify that the proposed equipment and methods of installation are compatible with the existing conditions and prepare a corresponding written report of their findings.

C. Design professional shall be notified in writing if modifications of the existing building are required in order to accommodate the new equipment. These modifications shall be made only upon receiving written approval from Design professional.

D. Submit installation drawings for Design professional review and approval prior to implementation.

## 3.3 SYSTEM STARTUP

A. The Contractor shall not apply power to the system until after:

1. System and components have been installed and inspected in accordance with the manufacturer's installation instructions.
2. A visual inspection of the system components has been conducted to ensure that defective equipment items have not been installed and that there are no loose connections.
3. System wiring has been tested and verified as correctly connected as indicated.
4. All system grounding and transient protection systems have been verified as properly installed and connected, as indicated.
5. Power supplies to be connected to the system and equipment have been verified as the correct voltage, phasing, and frequency as indicated.

## 3.4 FINAL INSPECTION AND ACCEPTANCE

A. Completion of the installation, in-progress and final inspections, receipt of the test and as-built documentation including data input of all installed components and successful performance of the system for a six week period shall constitute acceptance of the system. Upon successful completion of the installation and subsequent inspection, Design professional shall be provided with a numbered certificate from the Manufacturer registering the installation.

END OF SECTION

**SECTION 28 31 00**

**FIRE DETECTION AND ALARM**

## PART 1 - GENERAL

### 1.1 GENERAL AND SPECIAL CONDITIONS

A. General Requirements of these specifications shall apply to the work in this section.

B. The Contractor shall furnish all equipment, materials, tools, labor, engineering, drawings, etc. necessary for a complete fire alarm system installation, with said systems being made ready for operation in accordance with the requirements of the Authorities Having Jurisdiction. The purpose of Owner furnished specifications and drawings is to convey to the Contractor the scope of work required, all of which the Contractor is responsible to furnish, install, adjust, and make operable. The omission by the Owner of any necessary system component as required by the Authorities Having Jurisdiction or in the specifications shall not relieve the Contractor of the responsibility for providing such necessity, without additional cost to the Owner. The Contractor shall examine all available documentation before submitting a bid that may be material to the performance of the work. No extra payments will be allowed to the Contractor as a result of extra work made necessary by a failure to do so. Any case of error, omission, discrepancy or lack of clarity shall be promptly identified to the Owner, Architect, and Engineer for clarification prior to the bid due date.

C. The Contractor shall provide all devices and equipment required by these specifications and drawings. Under no circumstances shall the Contractor delete any equipment or devices without the written directive of the Owner. Where there is a conflict between the drawings and the specifications the specifications shall take precedence.

D. The Contractor shall furnish and install any additional devices or equipment required for the fire alarm system to meet the requirements of the City of Los Angeles Fire Department plan review office. The contractor shall commence changes to the Scope of Work only upon written directive of the Owner.

### 1.2 PERFORMANCE GUIDELINES

A. Provide labor, materials, and equipment for complete and functional fire alarm and supervisory signaling system as outlined in these specifications and as shown on the drawings. The Contractor shall be responsible for compliance with all applicable project specifications as well as the following guidelines.

B. The guidelines are not intended to be all-inclusive and do not limit or define the Contractor's scope of work. The work includes the following:
   1. New point-addressable multiplex fire alarm control equipment, multiplex transponders, initiating devices, notification appliances, annunciators, switches, relays, software, and accessories.
   2. All required conduit, wiring, equipment, and labor for a complete system installation.
   3. All required Firestopping of any penetrations related to the fire alarm system.

4. Detailed shop drawings and submittal information. The Fire Alarm Contractor and the Electrical Contractor will be responsible for providing their own shop drawings.
5. Coordination of the work with other trades for this project and coordination with any other Owner projects in the facility ongoing at the time of Fire Alarm Contractor's work.
6. On-site project supervision.
7. Permits, fees, and other charges required for the work.
8. Record documents, including electronic CAD drawings.
9. Detailed and customized operating and maintenance instructions.
10. Training of Owner's personnel.
11. Operational guidelines.
12. System pre-testing and final testing.
13. Warranty of equipment and labor.

## 1.3 SYSTEM ABBREVIATIONS AND DEFINITIONS

A. ADA – Americans with Disabilities Act Standards for Accessible Design

B. AFF – Above Finished Floor.

C. AHJ – Authority Having Jurisdiction. The City of Los Angeles Fire Department.

D. Analog addressable – Fire alarm system technology that uses point addressable smoke and heat sensors connected to circuitry that transmit obscuration percentages and heat values to the control panel, and allows the control panel to make alarm decisions based on the information received.

E. Approved – Unless otherwise stated, materials, equipment or submittals approved by the Owner or AHJ.

F. Circuit – Wire path from a group of devices or appliances to a control panel or transponder.

G. Class “A” – Pathway Class Designation for Signaling Line Circuits as Defined in NFPA 72.

H. Class “B” – Pathway Class Designation for Signaling Line Circuits as Defined in NFPA 72.

I. E-Stop – Emergency Fuel System stop.

J. FAAP – Fire Alarm Graphic Annunciator Panel.

K. FACU – Fire Alarm Control Unit

L. FCC – Fire Command Center. The Main FCC is located in the DWP Bldg. and the Secondary FCC is located in QTA Bldg. A.

M. FM – FM Global.

N. FM Approved – Materials or equipment approved by Factory Mutual and included in the most recent edition of the FM Global Approval Guide.

O. HVAC – Heating Ventilating and Air Conditioning.

P. IDC – Initiating Device Circuit.

Q. LAX – Los Angeles International Airport

R. LAWA – Los Angeles World Airports

S. LED – Light Emitting Diode.

T. Listed – Materials or equipment included in a list published by a Nationally Recognized Testing Laboratory that maintains periodic inspection of production of listed equipment and materials.

U. LCD – Liquid Crystal Display.

V. Multi-Criteria Technology – Smoke detectors that use two or more detection technologies to detect smoke and fire. Such technology uses a smoke or fire signature from two or more sources to make an alarm decision.

W. NAC – Notification Appliance Circuit. The notification appliance circuit may consist of a strobe circuit or a horn circuit.

X. Network – The arrangement of wiring or circuits between the fire alarm control panel and remotely located sub-panels (nodes).

Y. NFPA – National Fire Protection Association.

Z. Owner – Los Angeles World Airports

AA. SLC – Signaling Line Circuit.

BB. Transponder – Single or multiple zone/point data collection panel used within a multiplex system.

CC. UL – Underwriters Laboratories, Inc.

DD. UL Listed – Materials or equipment listed by Underwriters Laboratories and included in the most recent edition of the UL Fire Protection Equipment Directory.

EE. Zone – Combination of one or more circuits or devices in a defined building area, (e.g. 3 horns circuits on a floor combined to form a single zone.) Ultraviolet wavelength in regards to the spectrum of visible light

FF. Zone – Combination of one or more circuits or devices in a defined building area, (e.g. 3 horns circuits on a floor combined to form a single zone.)

## 1.4 RELATED WORK

A. Materials and methods specified in other sections:
   1. Elevators, Section 14 20 00.
   2. Fire Protection, Section 21 13 00.
   3. General Electrical, Section 26 00 00, except where modified in this section.

B. Materials furnished and installed by Others but wired by this Contractor:
   1. Sprinkler waterflow devices, valve supervisory devices and other sprinkler supervisory devices are being provided by the Fire Protection Contractor under a separate contract. The Fire Alarm Contractor shall wire these devices to the fire alarm system.
   2. The E-Stop interconnections at the main fire alarm panel shall be terminated by the Fire Alarm Contractor.
   3. Elevator controls shall be wired to the fire alarm system for elevator recall. The Elevator Contractor will perform final connections to the elevator controls.

## 1.5 PERFORMANCE REQUIREMENTS

A. Provide a UL listed, FM approved analog point addressable, multiplex fire alarm system. Approved manufacturers are listed in the Part 2 - Products section. The system shall include the following:
   1. The main FACU is to be located in the FCC located in the DWP Building
   2. A remote FACU is to be located in the Secondary FCC located in QTA Building A.
   3. Graphic annunciator panels will be provided at both FCC control equipment locations with LEDs to show the location of any activated device.
   4. The fire alarm system will provide outputs for all alarm, trouble, and supervisory signals to a UL listed central Station.

B. All required Smoke detectors, heat detectors, Flame detectors, waterflow devices, supervisory devices, and other initiating devices; notification appliances; control relay modules; and monitoring relay modules.

C. System Circuit Wiring:
   1. All multiplex data transmission circuits shall be NFPA 72, Class A, supervised signaling line circuits from the fire alarm control panel (FACU). The return wire shall be installed in a separate conduit.
   2. All fire alarm initiating device circuits shall be NFPA 72, Class A, electrically supervised circuits from the RTP or point addressable interface modules to the devices.
   3. All strobe notification appliance circuits shall be NFPA 72, Class B, electrically supervised circuits from the RTP to the appliances.
   4. All audible notification appliance circuits shall be NFPA 72, Class B, electrically supervised circuits from the RTP to the appliances.

## 1.6 SYSTEM OPERATION

A. The point addressable fire alarm and supervisory signaling system shall perform the following functions:
   1. Continuous monitoring of the status of all fire alarm and supervisory signal initiating devices.
   2. Visible point annunciation of all fire alarm point alarm and trouble conditions on the FACU and at the FCC.
   3. Continuous monitoring of all fire alarm panels.
   4. Operation of indicated control functions.

B. Change in status of any initiating device on the system shall:

1. Activate audible and visible status change indicators and display the system point number, point description, status, and message associated with the point on the FACU and remote monitoring location.
2. Permanently record the change in status, time, date, point description, and message associated with the point in fire alarm system historical event memory.

C. Activation of any waterflow, smoke detector, heat detector supervisory or other initiating device on the system will cause the following functions to occur:
   1. Manual station operation shall:
      a. Activate audible and visible status change indicators and display the system point number, point description, status, and message associated with the point on the FACU.
      b. Record the change in status, time, date, point description, and message associated with the point in fire alarm system historical event memory.
      c. Activate the audible and visible notification appliances throughout the building.
      d. Light the appropriate zone/point light on the annunciators at the Main FCC and Secondary FCC locations.
      e. Activate output to Emergency Fuel Stop System.
      f. Transmit an alarm signal to the UL Listed Central Station.
   2. Master Emergency manual E-stop shall:
      a. Activate audible and visible status change indicators and display the system point number, point description, status, and message associated with the point on the FACU.
      b. Record the change in status, time, date, point description, and message associated with the point in fire alarm system historical event memory.
      c. Light the appropriate zone/point light on the annunciators.
      d. Activate the audible and visible notification appliances throughout the building.
      e. Transmit an alarm signal to the UL Listed Central Station.
   3. Waterflow switch operation shall:
      a. Activate audible and visible status change indicators and display the system point number, point description, status, and message associated with the point on the FACU.
      b. Record the change in status, time, date, point description, and message associated with the point in fire alarm system historical event memory.
      c. Activate the audible and visible notification appliances throughout the building.
      d. Light the appropriate zone/point light on the annunciators at the Main FCC and Secondary FCC locations.
      e. Activate output to Emergency Fuel Stop System.
      f. Transmit an alarm signal to the UL Listed Central Station.
      g. Activate bells above fire department connections.
   4. Smoke detector and heat detector operation shall:
      a. Activate audible and visible status change indicators and display the system point number, point description, status, and message associated with the point on the FACU.
      b. Record the change in status, time, date, point description, and message associated with the point in fire alarm system historical event memory.
      c. Activate the audible and visible notification appliances throughout the building.
      d. Light the appropriate zone/point light on the Graphic annunciators at the Main FCC and Secondary FCC locations.

e. Activate output to Emergency Fuel Stop System.
a. Transmit an alarm signal to the UL Listed Central Station.

5. Fuel Island Optical Flame Detection operation shall:
   a. Activate audible and visible status change indicators and display the system point number, point description, status, and message associated with the point on the FACU.
   b. Record the change in status, time, date, point description, and message associated with the point in fire alarm system historical event memory.
   c. Light the appropriate zone/point light on the Graphic annunciators at the Main FCC and Secondary FCC locations.
   d. Activate output to Emergency Fuel Stop System.
   e. Transmit an alarm signal to the UL Listed Central Station.
   f. Activate the audible and visible notification appliances throughout the building.
6. Fuel Leak E-Stop or E-Stop Button shall:
   a. Activate audible and visible status change indicators and display the system point number, point description, status, and message associated with the point on the FACU.
   b. Record the change in status, time, date, point description, and message associated with the point in fire alarm system historical event memory.
   c. Light the appropriate zone/point light on the annunciators at the Main FCC and Secondary FCC locations.
   d. Activate the audible and visible notification appliances on the floor of the alarm.
   e. Transmit an alarm signal to the UL Listed Central Station.
7. Elevator lobby smoke detector operation shall:
   a. Activate audible and visible status change indicators and display the system point number, point description, status, and message associated with the point on the FACU.
   b. Record the change in status, time, date, point description, and message associated with the point in fire alarm system historical event memory.
   c. Light the appropriate zone/point light on the annunciators at the main FCC and Secondary FCC locations.
   d. Immediately recall the affected elevators to the designated floor. If the alarm is on the lobby level, recall the elevators to the alternate level.
8. Elevator machine room smoke detector operation shall:
   a. Activate audible and visible status change indicators and display the system point number, point description, status, and message associated with the point on the FACU.
   b. Record the change in status, time, date, point description, and message associated with the point in fire alarm system historical event memory.
   c. Light the appropriate zone/point light on the annunciators at the main FCC and Secondary FCC locations.
   d. Immediately recall the affected elevators to the designated floor.
   e. Activate the elevator “Top Hat” light inside the elevator car.
9. Sprinkler valve supervisory device, generator monitoring point, or other supervisory device activation shall:
   a. Activate audible and visible status change indicators and display the system point number, point description, status, and message associated with the point on the FACU.

b. Record the change in status, time, date, point description, and message associated with the point in fire alarm system historical event memory.
c. Light the appropriate zone/point light on the annunciators at the main FCC and Secondary FCC locations.
d. Transmit a supervisory signal to the UL Listed Central Station.

D. Removal of any device, wiring disarrangement, or system component failure shall activate audible and visible status change indicators and display the system point number, point description, status, and message associated with the point on the FACU and remote fire command station. When any point in the system returns to normal, the system shall:
1. Activate audible and visible status change indicators and display the system point number, point description, status, and message associated with the point on the FACU.
2. Acknowledgment of "system return to normal" will print the time, date, point identification and message. The acknowledgment will also silence all audible indicators associated with the point at the FCC.

E. Individual system testing and override switches shall be provided for the following functions:
1. Elevator Recall testing bypass.
2. Central Station Disconnect.
3. Horn/Strobe circuit testing bypass.

## 1.7 APPLICABLE STANDARDS

The following standards and guides (of the issue indicated) are hereby made a part of this work by reference thereto:

A. City of Los Angeles Building Code – 2014 edition

B. City of Los Angeles Fire Code – 2014 edition

C. City of Los Angeles Electrical Code – 2014 edition

D. NFPA 72 – National Fire Alarm Code – 2013 edition with local amendments

E. UL Standard 268, Smoke Detectors for Fire Protective Signaling Systems, latest edition.

F. UL Standard 464, Audible Signal Appliances, latest edition.

G. UL Standard 521, Heat Detectors for Fire Protective Signaling Systems, latest edition.

H. UL Standard 864, Control Units for Fire Protective Signaling Systems, 9th edition.

I. UL Standard 1424, Cables for Power-Limited Fire Protective Signaling Systems, latest edition.

J. UL Standard 1481, Power Supplies for Fire Protective Signaling Systems, latest edition.

K. UL Standard 1971, Signaling Devices for the Hearing Impaired, latest edition.

L. ADA Standards for Accessible Design, latest edition.

M. American Society of Mechanical Engineers (ASME)/American National Standards Institute (ANSI) A17.1, Elevator Code, latest edition.

## 1.8 SUBMITTALS

A. The Fire Alarm Contractor is fully responsible to completely plan the fire alarm system and certify the submittals meet the applicable codes and standards.

B. Submit the following information in a "Project Manual". Project manual shall be tabbed or otherwise sectioned by topic and bound by means intended to hold sheets together in booklet form:
1. Table of Contents,
2. Manufacturer's data sheets with equipment to be used highlighted or indicated,
3. Wire data sheets,
4. Equipment dimensions,
5. Installation instructions for all equipment,
6. Equipment testing procedures,
7. Equipment maintenance manuals,
8. Complete list of spare parts recommended by manufacturer,
9. Software information (see below),
10. All required calculations,

C. Submit the following software information:
1. Proposed point numbers,
2. Point descriptors,
3. Complete sequence of operations with input/output matrix for all points and
4. English action messages.

D. Submit newly prepared information created with a Revit program and drawn accurately to scale. Submit the following shop drawing information:
1. Complete panel layouts showing all field terminations,
2. Complete panel layouts showing location of all modules, power supplies and batteries,
3. Complete system riser diagrams and circuits, with candela ratings noted on strobes,
4. FACU panel elevations, graphic annunciator panel elevations, RTP panel elevations,
5. Complete floor plans showing all devices with point numbers for all initiating and notification devices and all wire between devices,
6. Candela rating for each strobe device labeled adjacent to the strobe device on the floor plans,
7. All conduit and/or wire routing for each SLC and notification appliance circuit with conduit shall be clearly identified where installed,
8. Wiring diagrams of all equipment,
9. Identify on the drawings the electrical panels providing the local normal or emergency 120 VAC to each FACU, RSP, and RTP.
10. Graphic layouts proposed for FCC annunciation,

E. Submit the following system calculations:
1. Standby battery capacity for fire alarm (identifying both the non-alarm and alarm load associated with each, and demonstrate conformance to the requirements of these specifications),

2. Standby battery capacity for all fire alarm panels (identifying both the non-alarm and alarm load associated with each, and demonstrate conformance to the requirements of these specifications),
3. Voltage drop calculations for each type of circuit (identifying all mathematical formulas, variables, constants, and sources of the mathematical constants),
4. Horn/Strobe zone/circuit loading calculations based on the UL Maximum Current method utilizing RMS current,
5. Normal 120 VAC fire alarm panel(s) circuit loading,
6. Normal 120 VAC remote panel circuit loading.

F. Prior to start of construction, submit the information outlined in A, B, C, D, E, and F above to the following:
   1. Three (3) complete submittal packages to the City of Los Angeles Fire Department for review.
   2. Two complete submittal packages to JENSEN HUGHES for review.
   3. One complete submittal package to the Owner for review.
   4. **PARTIAL SUBMITTALS ARE UNACCEPTABLE.**

G. Costs incurred by the Owner for JENSEN HUGHES, or the City of Los Angeles Fire Department, or DOB to review additional submittals resulting from an initial rejection shall be the responsibility of the submitting contractor.

## 1.9 WARRANTY

A. This Contractor shall provide a one year written warranty against defects in material and workmanship furnished under this Contract. The costs of such warranty shall be part of the purchase price. The warranty commences when the system and installation are accepted by the City of Los Angeles Fire Department, JENSEN HUGHESJENSEN HUGHES, and the Owner.

B. The warranty shall include all necessary material, travel, labor, and parts to replace defective components or materials at the job site. This Contractor shall commence repair of any "in warranty" defects within 4 hours of notification of such defects. The warranty shall include all after hours labor.

C. The warranty shall include all necessary factory and field software required to perform the specified tasks. This item does not include software installed after system acceptance unless the defective software was installed at the direction of the system manufacturer.

D. The Contractor shall make allowances in the warranty to cover diagnosis of system defects that may ultimately be the responsibility of others to correct. When this occurs, the Owner and other affected trades shall be notified.

E. If the Owner experiences more than two spurious or unexplained false alarms or troubles in any 48 hour period while the system is under warranty, the Contractor shall provide the necessary labor, materials, and technical expertise to promptly correct the issues without additional cost.

F. The Contractor shall include, as part of the warranty, a test, and inspection of the entire fire alarm system to be completed at least one month prior to the expiration of the construction warranty. The Contractor shall provide a written report of any deficiencies and repair all of the

deficiencies. The test and report shall conform to the certification described in NFPA 72 and as required by the City of Chicago.

## 1.10 DELIVERY, STORAGE AND HANDLING OF MATERIALS

A. Contractor will deliver all materials to area of project designated by Owner's representative. Vehicles shall not block fire lanes or fire doors during delivery of materials.

B. The Owner's representative will designate an area within the facility for storage of all materials. At the end of each working day, all materials shall be returned to the designated area. Material, equipment, tools, etc. will not be left outside the storage area without the consent of the Owner's representative.

C. The cost of all material handling, delivery, and freight is the Contractor's responsibility. The Owner or their representatives will not be responsible for materials delivered to the site.

D. Maintain premises free from accumulation of waste materials or rubbish caused by this work. At the completion of the work, remove all surplus materials, tools, etc., and leave the premises clean to the Owner's satisfaction.

## 1.11 QUALITY ASSURANCE

A. The Contractor shall have successfully completed three (3) projects of similar size and complexity within the past 5 years.

B. The fire alarm system manufacturer shall maintain a fully staffed branch office including NICET certified (or other professionally certified or registered) application engineers, drafters, and NICET certified technical service personnel within the Los Angeles metropolitan area. NICET certifications to be Level II or higher in Fire Alarm Systems.

C. All supplied equipment shall be standard products of the manufacturer and regularly stocked within the manufacturer's branch office.

D. The installation contractor shall be able to demonstrate the availability of an experienced staff for planning, engineering, installing, commissioning, training, and maintaining the multiplex fire alarm system. All fire alarm equipment installation personnel used by the contractor's shall be NICET certified in Fire Alarm Systems. A copy of such certifications shall accompany submitter's proposal.

E. All technical service personnel shall be regularly employed by the fire alarm system manufacturer or an authorized distributor.

F. All electrical installation of the fire alarm system, including wire installation and terminations, shall be performed by electricians in the employ of the Electrical Contractor.

G. Any subcontractors used to install portions of the system shall be approved by the Owner and JENSEN HUGHES prior to commencement of the installation.

H. All supplied equipment shall be current standard products of the manufacturer and regularly stocked within the manufacturer's branch or office for the next ten years.

## 2.1 MANUFACTURERS

A. Provide a UL listed and FM Approved point addressable multiplex fire alarm control system at the FCC.

B. Products for this project shall be of the latest design. Obsolete or discontinued models are not acceptable.

C. All equipment supplied shall be UL listed and FM Approved for the required function.

D. All fire alarm equipment shall be a product of one system manufacturer.

## 2.2 FIRE ALARM CONTROL PANEL (FACU)

A. The FACU's for the Main and Secondary FCC's shall be wall mounted and equipped with locked enclosures having removable access panels for servicing of electronic components. The FACU shall be completely pre-wired requiring only the connection of incoming field wiring and the plugging in of accessory modules such as additional memory, printer interface boards, etc. All controls and displays shall be mounted at heights allowing easy access by operating personnel. The FACU shall include, but not be limited to, the following major components, some of which may be physically separate from the main cabinet:
1. Central processing equipment.
2. Normal AC power supplies.
3. Network data transmission equipment.
4. Emergency power supplies.
5. LCD display screen.

B. The computer based point addressable FACU shall be listed in accordance with UL 864, 9th Edition. Use of non-UL Listed computers is strictly forbidden.
1. The main memory system shall be adequately sized to provide display, printout, and control of 150% of the actual alarm and command points as described herein and indicated on the drawings.
2. All basic alarm and control software shall be included.
3. The FACU shall be equipped with a nonvolatile main memory system of EPROM or EEPROM memory system.

C. Fixed graphic annunciators of building floor plans as shown in the design drawings shall be provided in the Main and Secondary FCC's.

D. LED annunciator modules with a minimum of eight zones on each module consisting of one red alarm LED and one yellow LED per zone. LED modules shall be provided in the main control cabinet or as part of the fixed graphic annunciators of sufficient quantity to meet the requirements of the City of Los Angeles Fire Department.
1. Provide a red alarm LED and yellow trouble LED for each sprinkler waterflow switch and alarm device type.
2. Provide a red alarm LED for each Fuel Island Detection zone.
3. Provide a red alarm LED and yellow trouble LED for each floor detection zone.
4. Provide a red alarm LED and yellow trouble LED for each manual pull station.

5. Provide additional cabinets as required.

E. The system operating terminal shall be the liquid crystal display (LCD) type. The LCD shall include, at a minimum, control function keys, digital display window with a minimum of 80 characters, programming buttons, and key-operated lockout capability. The time shall be permanently displayed on the LCD and shall be visible at all times. The LCD shall allow the operator to perform the following minimum tasks:
1. Inquire point status.
2. Start or stop equipment manually.
3. Test and reset equipment manually.
4. Bypass control points during manual system tests.
5. Initiate control by event sequences.
6. Manually request "logs" of system status.
7. Acknowledge status changes.
8. Silence local alarm sounder.
9. Monitor and control analog smoke detector sensitivity.

F. Normal operating power for the FACU shall be 120 volt AC supplied from dedicated circuits. All circuits shall be protected by locking circuit breakers of proper size.

G. The fire alarm system shall be provided with an emergency standby power system consisting of backup batteries. Batteries shall be sealed lead-acid or gel cell of sufficient capacity to provide 24-hour standby operation plus 5 minutes in full alarm condition. All calculations shall allow a minimum of 20% safety factor for battery degradation. Batteries shall be mounted in a separate vented enclosure.

H. The FACU shall accommodate all specified initiating device, notification appliance and command points. Any additional addresses required by a vendor’s equipment shall be included as part of the base system.

I. Provide a system smoke detector above the FACU if installed in an area that is not protected by smoke detection

## 2.3 REMOTE TRANSPONDER PANELS (RTP)

A. Remote transponder panels (RTP) shall be provided where shown. The cabinets shall be surface mounted with a locking door or cover.

B. Remote transponder panels (RTP) shall function as a peer-to-peer control unit and shall be provided where shown. The cabinets shall be surface mounted with a locking door or cover.

C. The RTP panels shall accommodate all specified initiating device and command points. Each initiating circuit shall allow a 10% expansion of connected detection devices and 10% expansion of connected monitor/control points. All assemblies within the RTP panels shall be modular to allow for expansion and servicing of equipment. All power supplies, standby power, motherboards, and terminal strips shall be included to accommodate specified future expansion so that expansion can be accomplished by simple installation of circuit boards and wiring to remote devices.

D. Normal system power shall be 120 volt AC power provided by dedicated circuits. All circuits shall be protected by locking circuit breakers of proper size.

E. The RTP panels shall be provided with an emergency standby power system consisting of backup batteries. Batteries shall be sealed lead-acid or gel cell of sufficient capacity to provide 24 hour standby operation plus 5 minutes in full alarm condition. All calculations shall allow a minimum of 20% safety factor for battery degradation. (Batteries shall be mounted in a separate vented enclosure.) Emergency power circuit shall recharge the unit to normal capacity within 48 hours of restoration of normal power. One emergency power supply unit may power more than one RTP cabinet if all such cabinets are at one location. The loss of AC or DC power at any RTP shall cause a distinct power failure signal.

F. The RTP cabinets shall accept input/output (initiating, supervision, notification, and/or command) modules for the specified points, zones and spares. The type of input/output modules shall include, but not be limited to the following:
1. Addressable device data transmission, supervision, control, and power. Addressable loops shall originate from the RTP.
2. System configurations with addressable loops originating from the main fire alarm control panel do not comply with this requirement.
3. UL listed for releasing device service where required.
4. Horn/Strobe supervision, synchronization, and control circuit modules providing Class B electrically supervised circuits. Power supplies and modules that do not provide individual circuit troubles at the main network control panel are not acceptable.
5. Addressable device data transmission, supervision, control, and power.

G. The RTP panels shall accommodate all specified horn circuits, strobe circuits, and telephone circuits. Each notification appliance shall allow a 10% expansion of connected devices. All assemblies within the RTP panels shall be modular to allow for expansion and servicing of equipment. All power supplies, standby power, motherboards, and terminal strips shall be included to accommodate specified future expansion so that expansion can be accomplished by simple installation of circuit boards and wiring to remote devices.

H. Provide a system smoke detector above the FACU if installed in an area that is not protected by smoke detection.

## 2.4 REMOTE STROBE POWER SUPPLIES (RSP)

A. Remote Power Supplies shall include:
1. A minimum of four notification appliance circuit monitoring and control modules. The modules shall be designed to meet the required circuit configurations.
2. Strobe synchronization modules.
3. Power supply with battery charger and standby batteries. Batteries shall be sized to meet the standby requirements of the FACU.
4. Supervision and activation by the main fire alarm system. Trouble conditions for each power supply shall be supervised by a separate point addressable monitor module that is independent from the associated trigger circuit or control module.) (Power supplies and modules that do not provide individual circuit troubles at the main control panel are not acceptable.

B. Provide a system smoke detector above each panel if the panel is installed in area not protected by smoke detection.

C. Each remote strobe power supply shall be activated by an individual point addressable control module or the strobe power supply shall be point addressable and individually commanded by the main fire alarm control panel.

D. Activation of strobe circuits by cascading of strobe power supplies shall not be acceptable.

E. Normal operating power for the FACP shall be 120 volt AC supplied from dedicated circuits of the local emergency power panel. All circuits shall be protected by locking circuit breakers of proper size.

## 2.5 POINT ADDRESSABLE SYSTEM SOFTWARE

A. As part of the initial system installation, provide all executive system software for the fire alarm system including, but not limited to, the following:
1. Basic alarm processing programs.
2. Control by event programs.
3. System point scanning routines.
4. Password control routines.
5. Emergency file display routines.
6. Smoke detector sensitivity routines.

B. Provide as part of the system all preparation and installation of data files including, but not limited to, the following:
1. Point descriptions.
2. Control by event sequences.
3. Emergency file statements.
4. Print statements.
5. Password installation.

C. Systems which rely on EPROM shall be factory reprogrammed at no additional cost to the Owner as many times as required until the system is accepted by the Owner, JENSEN HUGHES, and/or Fire Prevention Bureau.

D. Point/zone descriptions shall consist of English language statements that adequately define the point or zone. The use of abbreviations shall be limited to commonly used fire alarm system abbreviations.

E. System emergency file statements shall be assigned to individual points/zones to assist operator response to an emergency condition. The emergency file shall consist of English language statements that adequately define the desired action. The use of look-up tables is expressly forbidden.

## 2.6 ALARM INITIATING DEVICES

A. Provide point addressable manual stations where indicated. The manual stations shall be single-action type, red with white lettering, and shall be mounted in the required locations unless otherwise noted:

1. Surface mounted stations shall mount on a UL listed, red, smooth sided back box provided by the manufacturer. Semi-flush mounted stations shall mount on a standard electrical box.
2. Operation of a manual station shall cause its contacts to manually lock-in until manually reset and visibly indicate that the station was activated.
3. Manual stations in garages or other unheated spaces shall be conventional hardwired devices similar to Wheelock Model MPS-100 with MPS-WP back box and gasket. The point monitoring module mounted in a condition space.

B. Provide point addressable manual fuel release stations where indicated. The manual fuel release stations shall be single-action type, color coded with white lettering, and shall be mounted in the required locations unless otherwise noted:
   1. Surface mounted manual fuel release stations shall mount on a UL listed, smooth sided back box provided by the manufacturer. Semi-flush mounted stations shall mount on a standard electrical box.
   2. Provide a Stopper II clear cover for all manual fuel release stations to prevent inadvertent activation of the station.
   3. Manual fuel release stations shall be conventional hardwired devices similar to Wheelock Model MPS-100 with MPS-WP back box and gasket. The point-addressable monitoring modules shall be located in accessible locations outside of the Alarm Zone.

C. Vane type waterflow devices shall be provided by the Fire Protection Contractor where indicated on all wet pipe sprinkler systems. The waterflow device shall contain a suitable, adjustable retard device, and actuate upon flow from a single sprinkler. Waterflow devices shall be housed in a substantial metal housing with a gasketed cover. The devices shall be initially adjusted to actuate within 30 to 60 seconds after the inspector's test valve is opened.

D. Point addressable, analog, photoelectric type smoke detectors shall be provided where indicated. The smoke detectors shall be provided with integral LEDs to indicate detectors in alarm. Line transient and RFI protection shall be built into the detector.

E. Multi spectrum Flame Detectors similar to Spectrex Model 40\40I optical flame detectors rated for hazardous locations shall be provided as follows:
   1. All fire alarm monitoring devices shall be set up for intrinsically safe operation.
   2. Fueling Islands shall have zoned detection per floor.
   3. The Flame Detectors will be hardwired to point–addressable monitoring modules located in accessible locations outside of the Alarm Zone.

F. Addressable point monitoring modules shall be used to monitor the waterflow devices, optical flame detectors, and similar alarm initiating device relays.
   1. The interface modules shall provide Class B electrical supervision of monitored devices and be equipped with terminal strips or terminal blocks.
   2. Each monitor module shall be equipped with integral LED that indicates when the device being monitored is in alarm.
   3. Monitoring modules used for initiating and indicating devices appliances located within the Fuel Island Alarm Zones shall be located in accessible locations outside of the Alarm Zone.
   4. All monitoring modules are to be located in accessible locations.

## 2.7 SUPERVISORY INITIATING DEVICES

A. Valve supervisory devices shall be monitored for all sprinkler control valves provided by the Fire Protection Contractor. The valves to be supervised may be OS&Y or butterfly-type, or a combination of both. All switches shall be SPDT with gasketed rain-tight enclosures. The valve supervisory devices shall be installed to transmit a supervisory signal within the first two turns of the control valve handle. Wiring the sprinkler supervisory devices on the same initiating device circuit with the waterflow switch is forbidden.

B. Addressable point monitoring modules shall be used to monitor all supervisory points. The monitoring modules shall provide Class B electrical supervision of monitored devices.
   1. The interface modules shall provide Class B electrical supervision of monitored devices and be equipped with terminal strips or terminal blocks.
   2. Each monitor module shall be equipped with integral LED that indicates when the device being monitored has activated.

## 2.8 ALARM NOTIFICATION APPLIANCES

A. Horns for non-hazardous locations shall be provided where indicated. The horn shall be set to provide continuous sounding as required by the AHJ:
   1. Surface mounting back boxes for combination horn/strobe units shall be red.
   2. ALL back boxes shall be weather resistant WBB weather resistant back box. Sturdy die cast housing, threaded conduit, knockout for outdoor applications, and painted to match the signal.

B. Horns and strobes for hazardous locations and harsh environments shall be factory assembled in combination on a stainless steel mounting plate and shall be factory wired for simultaneous operation of the horn and strobe from a single input.

C. Strobe units, listed to UL Standard 1971, shall be provided where required. The units shall be semi-flush type, wall mounted, and/or ceiling mounted. The units shall operate on 24 volt DC polarized power.
   1. Multi-Candela appliances shall have field selectable settings and shall be rated per UL Standard 1971 at 15/30/75/110 candela or 135/185 candela for wall mount and 15/30/75/95 candela or 115/177 candela for ceiling mount and have a flash rate of 1 Hertz.
   2. The strobe intensity selector switch for selecting the candela rating shall be tamper resistant. All strobes shall be synchronized from the FACU, RSP, or RTP.
   3. All wall mounted strobes shall be mounted between 80 inches AFF and 96 inches AFF unless otherwise noted or approved.
   4. Strobes may be combined with horns where shown on the bid drawings.

D. Strobes for hazardous locations and harsh environments shall be UL listed for Class I, Division 2, Groups C&D, and Class I, Zones 1 & 2, AExd IIB T5 applications and shall be listed under UL Standard 1638 for Indoor/Outdoor use. The strobe appliances shall be constructed of lightweight, UV stable glass reinforced polyester, shall be corrosion resistant, and shall meet NEMA 4x, NEMA 6, IP 66 & IP 67 environmental requirements over a temperature range of -67°F to 158°F (-55°C to 70°C). These strobes shall be similar to Edwards 116DEGEX-FJ.
   1. The strobe shall be rated at 125 candela ceiling mounted and 60 candela wall mounted. Rated current draw shall not exceed 320 mA at 24 vdc.
   2. The strobe shall be capable of direct surface mounting in any direction.

E. Sync modules shall be provided where required. If the Sync Modules contacts fail in the passive state (i.e., contacts remain closed) the strobe shall revert to a non-synchronized flash rate of one (1) flash per second. Strobe shall meet UL 1971 and produce a flash rate of one (1) flash per second minimum over the listed input voltage (16 VDC – 31 VDC) range.

F. Sprinkler bells shall be UL Listed for Fire Protective Service with steel shells 10 inches diameter shall be provided at exterior fire department connections. Sound output at 10 feet shall range up to 88 dBA. The bells shall semi-flush mount to standard 4 inch square back boxes or surface mount to outdoor back box. All bell models shall be polarized for line supervision and shall have screw terminals for in-out field wiring. The finish on all models shall be red enamel. Bells shall be powered by the fire alarm system notification circuit and rated at nominal 24VDC.

G. The notification appliances shall provide the following minimum sound pressure levels:
1. 15 dBA above ambient sound levels.
2. 5 dBA above maximum sound levels.
3. 70 dBA in office spaces.
4. 70 dBA in public spaces and 15 dBA over ambient sound levels.
5. 90 dBA in mechanical areas.

## 2.9 CONTROL DEVICES

A. Power supplies used for operation of control relays, contacts, step-down relays, or similar applications shall be supervised by the fire alarm system for trouble conditions.

B. Provide control relays/contacts for elevator recall where required. The control relays/contacts shall be 24-volt DC low voltage type, each with number of contacts required and housed in metal enclosure. The contacts shall be rated as required for continuous duty.

C. Addressable point control devices shall be used to provide all required control functions. Control devices used for activation of fire suppression systems or similar releasing equipment shall be listed for Releasing Service. Control relays connected to unsupervised circuits shall be located within 3 feet of the controlled device.

D. All power supplies and addressable control relays shall be located in accessible locations.

E. Power supplies and addressable control relays located in exterior areas shall be installed in weather resistant back boxes or enclosures.

## 2.10 FIXED GRAPHIC ANNUNCIATORS

A. Graphic Annunciator panel shall conform to the following:
1. Provide a red LED for each sprinkler alarm device zone near the approximate location of the device on the graphic floor plan.
2. Provide a red LED for each flame detection zone near the approximate location of the device on the graphic floor plan.
3. Provide a red LED for each manual pull station near the approximate location of the device on the graphic floor plan.
4. Provide a yellow LED for each supervisory device near the approximate location of the device on the graphic floor plan.

5. Provide a yellow LED for indication of trouble conditions. Provide green LED's for indication of power supervision.
6. Graphic representation shall be a photo emulsion applied to a layer of Plexiglas, protected by a layer of non-glare Plexiglas. As a minimum, graphic layout shall include building footprint, stairs, elevators, and zone designations. Proposed layouts shall be approved by the Owner, AHJ, and JENSEN HUGHES prior to fabrication.
7. Electronic drivers, power supplies, and any other components required for proper operation shall be enclosed in the manufacturer's surface mounted panel equipped with a continuous hinge and lock.

B. Fixed graphic annunciators of building floor plans as shown in the design drawings shall be provided in FCC and in the Support Building. The scale of the floor plans shall be 1/16 inch.

C. Back boxes for the fixed graphic annunciators shall be a minimum of 36 inches wide by 48 inches high. Sufficient space should be available for two floors per back box.

## 2.11 FIRE COMMAND CENTER (FCC)

The FCC shall be provided where indicated on drawings or in design criteria. The new FCC shall include:

A. Fixed graphic annunciators of building floor plans.

B. Zone/point fire alarm annunciator panels.

C. Emergency power annunciators.

D. Elevator status panels (by Others).

E. Relay output modules to interface with E-Stop equipment.

## 2.12 REMOTE TRANSMITTING EQUIPMENT

A. Remote Monitoring station:
1. Provide separate isolated fire alarm, trouble, and supervisory dry contacts at the fire alarm control panel.

B. Central Station:
1. Transmitters shall be provided by the contractor and meet the requirements of the UL Listed central station monitoring company. The central station monitoring company shall provide any telephone line filters required.
2. The remote transmitter shall be connected to two dedicated telephone lines (numbers) via RJ-31x telephone jacks.
3. The remote transmitter shall be connected to two dedicated telephone lines (numbers) via RJ-31x telephone jacks.
4. Transmitter shall be configured for daily test signal operation.

## 2.13 THE FIRE ALARM DOCUMENT BOX (FAD)

A. The Fire Alarm Document Box (FAD) shall be constructed of 18 gauge cold rolled steel, it shall have a red powder coat epoxy finish.

B. The cover shall be permanently screened with 1" high lettering "FIRE ALARM DOCUMENTS" with indelible ink.

C. The access door shall be locked with a 3/4" barrel lock and the hinge shall be a solid width 12" stainless steel piano hinge. The enclosure will supply 4 mounting holes.
   1. Inside the enclosure a removable steel sleeve that will accommodate standard 8 ½ x 11 manuals and loose document records that will be protected within the enclosure.
   2. A legend sheet permanently attached to the door for system passwords and critical information and inspection notes The FAD will have permanently and securely mounted inside a minimum of 2 Gigabyte digital flash memory drive with a standard USB B connector for uploading and downloading information.

D. The enclosure shall also provide 2 key ring holders with a location to mount standard business type cards for key contact personnel.

## 2.14 INSTALLATION MATERIAL

A. Wire shall be UL listed for use in fire alarm signaling systems or as required by NFPA 70, Article 760. All wire shall be solid conductors of copper, minimum size No. 18 AWG and insulation rated and labeled for non-power limited use.

B. All conduits, junction boxes, pull boxes and fittings shall be UL Listed and constructed of metal.
   1. Set screw connectors shall be pre-painted red and similar to Thomas & Betts TC123A-FA.
   2. Junction Boxes shall be pre-painted red, UL listed for use in 2-hour construction, and similar to RACO catalog series 911 square 4” welded boxes.
   3. EMT conduits shall be pre-painted red similar to Allied RED EMT with E-Z Pull coating.
   4. Rigid conduit and fittings shall be used for all garage piping and underground piping from Fire Control Center on the North side to the remote Fire Command Station at QTA Support building.
   5. Rigid Steel Conduit shall be hot-dip galvanized and manufactured by Allied Tube & Conduit.

C. Terminal Cabinets:
   1. Manufactured with 16 gauge cold roll steel with red finish.
   2. Equipped with factory mounted terminal strips designed to accept 12 gauge wires and rated at 20 amps maximum.
   3. Provided with lift away hinge and key lock.
   4. White lettering “FIRE ALARM TERMINAL CABINET”.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. The Fire Alarm System Supplier shall furnish on-the-job supervision for the proper installation of their devices in cooperation with, or as may be required by, other trades. This supervision shall include, but not be limited to, the following:

1. Provide specific on-site instructions to others on mounting and installation of each type of device by physically observing the mounting of one or more of each type of device, as required, to assure that the installer is properly instructed in the work.
2. Provide other supervision as required by the trades to properly perform alarm installation work.
3. Perform a complete test of the system, certifying that all devices have been activated and that the devices and systems perform in accordance with the requirements of these specifications and local codes.
4. Install, test, trouble-shoot, and correct all system software provided under these specifications. This includes, but is not limited to, actual keyboard entry, reprogramming required to meet these specifications and any other task associated with the system software.
5. Provide layout drawings and detailed wiring diagrams to the City of Los Angeles Fire Department as required by the Submittal section of these specifications and current City requirements.

B. The Fire Alarm Contractor shall furnish all material and labor to provide a complete and functional system that operates in accordance with the requirements of these specifications. This shall include, but not be limited to, the following:
   1. Conduit, raceway, and wiring systems as indicated herein.
      a. Install the fire alarm system in red conduit or approved raceway, parallel to building structure.
      b. In areas with suspended ceilings all conduit shall be installed above the ceiling.
      c. Strap or bundle all cables and wires inside equipment enclosures and terminal cabinets, parallel to the enclosure sides. There shall not be any coiled wire within any panel enclosures. All excess wire shall be coiled in a junction box in close proximity to the equipment panel enclosures.
      d. All wiring for this project will be new.
      e. Wire:
         (1) Wire used for 120 VAC power circuits shall be minimum size of 12 AWG stranded copper conductors, with THHN insulation.
         (2) Wire used for 24 VDC power circuits and strobe circuits shall be minimum size of 14 AWG stranded copper conductors, with TFN insulation and UL listed for fire alarm use and labeled PLFA.
         (3) Wire used for point addressable, signaling line circuits, and Network transmission systems shall be minimum size of 18 AWG solid copper conductor, UL listed for fire alarm system use and labeled PLFA.
         (4) Wire shall be UL listed for use in fire alarm signaling systems or as required by NFPA 70, Article 760. All wire shall be a solid conductor of copper, minimum size of No. 18 AWG and insulation rated at 600 volts.
         (5) All wire installed for this project shall be new and be UL listed for use in fire alarm systems.
         (6) All wire shall meet the requirements and recommendations of the system manufacturer.
         (7) All wire installed underground from Fire Control Center on the North side to the remote Fire Command Station at QTA Support building shall be rated as direct burial and installed in conduit.
   2. Power Supplies:

a. Dedicated primary 120 VAC power from the nearest emergency power panel or other dedicated breaker shall be connected to each fire alarm control panel, remote strobe power supplies.
b. Dedicated lockable breakers shall be provided for power circuits of the fire alarm system.
c. No fire alarm system 120 VAC primary power circuit shall be loaded beyond 80% of the circuit's rated capacity.
d. Design load connected to any power supply/standby battery shall not exceed 85% of its rated capacity.

3. Conduit:
   a. Conduit shall be 3/4-inch minimum size except where otherwise required by local code or these specifications.
   b. All EMT conduit fittings shall be compression type. Where required by the manufacturers to maintain the listing of the cable, set screw connectors shall be pre-painted red and similar to Thomas & Betts TC123A-FA.
   c. Use rigid conduit, liquid tight flexible conduit, weatherproof back boxes, and weather resistant conventional fire alarm equipment in all areas except fueling areas and office areas.
   d. Use rigid conduit underground piping from Fire Control Center on the North side to the remote Fire Command Station at QTA Support building.
   e. Flexible conduit and associated junction boxes connecting sprinkler waterflow and supervisory switches shall be water resistant.
   f. EMT conduits shall be pre-painted red similar to Allied RED EMT with E-Z Pull coating.
   g. Fueling areas use rigid conduit, fittings, back boxes, and conventional fire alarm equipment rated for Hazardous Location to comply with Class 1, Division 1 rating of the spaces.
   h. Rigid Steel Conduit shall be hot-dip galvanized and manufactured by Allied Tube & Conduit. Threads shall be hot galvanized after cutting. Rigid steel conduit shall be listed to UL Safety Standard 6 by a nationally-recognized testing laboratory with follow up service. It shall be manufactured in accordance with ANSI C80.1.Kwik-Couple Rigid steel conduit shall be listed to UL 6 and UL 514B and manufactured in accordance with ANSI C80.1.
4. Junction Boxes:
   a. Sectional boxes shall not be used.
   b. Each box shall be large enough to accommodate required splices and conduit in accordance with the NFPA 70 and the Chicago Electrical Code.
   c. All boxes and box covers shall be factory painted red. Junction Boxes shall be pre-painted red, UL listed for use in 2-hour construction, and similar to RACO catalog series 911 square 4" welded boxes.
   d. A junction box (the one used in conjunction with the Wiremold) shall be installed where fire doors are still in place in main corridors within 5 feet of each side of the door to facilitate the removal of the fire doors in future projects.
5. Field Terminal Cabinets (FTC):
   a. FTC shall be UL listed for use in electrical wiring systems.
   b. FTC shall be painted red with label "Fire Alarm Equipment" stenciled on cover.
   c. UL listed terminal strips shall be provided in all FTCs for all wiring splices in terminal boxes. All terminals shall be permanently labeled. The use of wire nuts to make wiring splices is strictly prohibited.

6. All coring and sleeving required.

C. Mounting:
1. Manual stations in finished areas shall be mounted in flush boxes unless otherwise noted. Manual stations located in unfinished areas shall be surface mounted on back boxes provided by the device manufacturer. All manual stations shall be mounted at 48 inches AFF measured to the pull lever.
2. Wall mounted horns shall be mounted a minimum of 96 inches AFF. Where ceiling height does not allow for these mounting heights, devices shall be mounted at 6 inches below ceiling height.
3. Wall mounted combination horns/strobes shall be mounted at 96 inches AFF. Where ceiling height does not allow for these mounting heights, devices shall be mounted at 6 inches below ceiling height.
4. All alarm devices, horns, and strobes shall be mounted in accordance with the manufacturer's installation instructions and use the manufacturer's suggested mounting box.
5. Point addressable monitor modules and control modules shall be securely mounted in back boxes or mounted on rails within a larger enclosure. The use of wire nuts to make connections to these modules is strictly prohibited. Integral Module LEDs shall be visible at all times without having to open the panel or box cover.
6. Panels including Fire Alarm and Annunciator panels shall be mounted so that no control switch or visible indicator will be installed less than 36 inches AFF or greater than 72 inches AFF.
7. All equipment panels visible to the public or as noted on the drawings shall be finished as directed by the Owner.

D. Device Spacing:
1. Strobes shall be spaced at intervals required by NFPA 72.
2. Corridor strobes shall be spaced not greater than 100 feet on center.
3. Optical flame detectors shall be spaced as shown on the drawings and in accordance with the manufactures recommendations.
4. Spot type smoke detectors installed in rooms shall be spaced not greater than 15 feet from a wall and not greater than 30 feet on center.

E. Circuit Design:
1. No strobe circuit shall be loaded beyond 80% of rated capacity. Strobe circuits shall be designed so that not more than one floor shall be on the same notification zone.
2. Strobe circuit design shall be based on current draw using UL Maximum Current Draw per appliance. No strobe circuit shall be loaded beyond 80% of rated capacity. Not more than one floor shall be on the same notification zone.

F. Device Labeling:
1. Use a P-touch electronic labeling system to label point numbers on the exterior of designated devices. Label shall be black on white background with lettering and/or numbering a minimum of 3/8 inch high.
2. The label shall include the device point number and function. The function would be similar to "Fire Pump Run" or "Valve Supervisory Switch".
3. The following devices shall be labeled:
   a. Monitor modules.
   b. Control modules.
   c. Smoke detectors, heat detectors, and flame detectors.

G. Lightning Arrestors:
   1. Provide lightning over voltage protectors on any circuit that contains devices or appliances located on the exterior of the building.
   2. The over voltage protectors shall mount in dedicated metallic electrical boxes as close as possible to the location where the circuits exit the building.

H. Pay for all permits, fees, and charges required for this work. This shall include, but not be limited to, the following:
   1. Fire Prevention Bureau reviews.
   2. Fire department system tests.

## 3.2 FIRESTOPPING

A. Firestopping shall be installed wherever the conduits penetrate floors and fire walls. The firestopping material shall meet the requirements of UL 1479.
   1. Install firestopping in accordance with the manufacturer's recommendations and as necessary to meet the specified fire rating requirements.
   2. Where firestopping is used to seal around penetration through waterproof membranes, install to maintain integrity of waterproof barrier.
   3. Contractor shall document specific fire stopping systems and methods used for each location. Documentation shall be issued to JENSEN HUGHES prior to field inspections.

B. Patching of all walls, floors, and ceilings that are penetrated or damaged during construction and returning the surface to a condition matching adjacent surfaces.
   1. All slab penetrations shall be completely sealed and made watertight.
   2. Restore all firewalls to rated conditions.

## 3.3 TESTS/FIELD QUALITY CONTROL

A. The final alarm acceptance test shall be coordinated with JENSEN HUGHES.

B. Prior to the acceptance test, the Contractor shall conduct a full pre-test of the system to verify proper operation. A letter certifying that the installation is complete and operational shall be forwarded to the Owner and JENSEN HUGHES.

C. One week prior to the start of acceptance testing, the Contractor shall provide JENSEN HUGHES with a printout of the system point numbers, point descriptions, English messages, event control description, and sequence of system operation.

D. One week prior to the start of the acceptance test, the contractor shall measure all circuits and record resistance, stray voltage, and other items required by NFPA 72. Measurement records shall be issued to JENSEN HUGHES at the start of the test.

E. The Owner, Contractor, Fire Alarm Contractor, Fire Alarm System Supplier, JENSEN HUGHES and an authorized representative from each supplier of equipment shall be in attendance at the final acceptance test to make necessary adjustments. A final test shall be conducted in accordance with NFPA 72 and City of Los Angeles Fire Department requirements. The test shall include, but not be limited to:
   1. A test of the complete system for grounded, open, and shorted circuits.

2. A test of each alarm-initiating device for functions specified and for the required alarm actions.
3. A test to verify smoke entry into sensing chamber of smoke detectors.
4. A test of the system for electrical supervision.
5. A test to verify that the emergency power source is capable of operating the system for specified periods.
6. A test to verify that alarm signals will operate under specified trouble conditions.
7. A test to verify that the system will operate under specified trouble conditions.
8. A test to verify that the system will perform all specified tasks.
9. A test to verify that audible sound level coverage has been achieved.
10. A test to verify remote monitoring transmission will operate as required.
11. A test to verify that a hard copy of all required system actions will be properly recorded.

F. During the system testing, the Contractor shall provide paper for the printer connected to the FACU to document system testing. The Contractor shall provide a copy of the printed record to JENSEN HUGHES.

G. The Contractor shall provide all materials, equipment, coordination, and personnel necessary to perform and document all required tests. All test equipment shall be subject to approval by the Owner and JENSEN HUGHES.

H. Contractor shall provide a minimum of one set two-way radios capable of operating in the facility for the duration of the test.

I. If the system requires a retest by JENSEN HUGHES or the City of Los Angeles Fire Department, all costs of the retest shall be the responsibility of the Fire Alarm Contractor.

## 3.4 TRAINING

A. Provide training of operating personnel in proper system operation and required user maintenance procedures.

B. Schedule training with Owner with at least fourteen (14) days' advance notice.

C. Three operating manuals containing illustrations, description of each detection device, operation of control panels, switches, pilot lights, etc.

D. Three separate 2-hour training sessions for operating personnel. These sessions are to cover proper operating and response procedures. These instructions shall be sufficient to enable a previously untrained person to properly operate the system.

E. Provide three software manuals containing a listing of all points, event programs, basic programming and instructions, and software trouble-shooting information.

## 3.5 RECORD DOCUMENTS

A. Provide one (1) reproducible print, two (2) Blackline prints, and a set of disks, CD-ROMs, or flash drives in Revit or later version of drawings, floor plans with device locations, Color LCD Floor slide layouts, device addresses, wire routing, and wiring diagrams reflecting "as-built" conditions to the Owner.

B. Provide CD-ROMs or Flash drives with all “as-built” drawings in Adobe PDF format.

C. Provide two (2) complete sets of "as-built" data sheets for all system-connected equipment to the Owner.

D. Provide one (1) complete set of "as-built" data sheets for all system-connected equipment to JENSEN HUGHES.

E. Provide two (2) sets of the complete "as-built" software listing of all data files, event programs, print statements, points list, etc. to the Owner.

F. Provide one (1) copy of all data files on CD-ROMs or flash drives to the Owner.

G. Provide two (2) sets of customized "as-built" operating manuals to the Owner. The manuals shall comply with the requirements of NFPA 72 item 4.5.2.3 including all information listed in A.4.5.2.3 (1).

H. Provide one (1) set of Blackline prints and a set of disks or CD-ROM or flash drive in Revit or later version of drawings, floor plans with device locations, device addresses, wire routing, wiring diagrams, and all system calculations reflecting "as-built" conditions to JENSEN HUGHES.

I. Provide a completed test form which complies with NFPA 72, signed and dated by the fire alarm system manufacturer or his agent.

## 3.6 SPARE PARTS

A. All spare parts shall be directly interchangeable with the corresponding components of the installed systems.

B. The Fire Alarm Contractor shall furnish a listing, in duplicate, of all spare parts and accessories that the manufacturer recommends to be stocked for proper maintenance of system.

**END OF SECTION 28 31 00**

# SECTION 31 10 00 - SITE CLEARING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. Section Includes:

1. Protecting existing vegetation to remain.
2. Removing existing vegetation.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Stripping and stockpiling rock.
6. Removing above- and below-grade site improvements.
7. Disconnecting, capping or sealing, and removing site utilities.
8. Temporary erosion and sedimentation control.

B. Related Requirements:

1. Section 015000 "Temporary Facilities and Controls" for temporary erosion- and sedimentation-control measures.

C. Related Requirements:

1. Section 01500 "Temporary Facilities and Controls" for temporary erosion- and sedimentation-control measures.

### 1.3 DEFINITIONS

A. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.

B. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil," but in disturbed areas such as urban environments, the surface soil can be subsoil.

C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil; the zone where plant roots grow.

D. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil; 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 larger than 2 inches (50 mm) in diameter; and free of weeds, roots, toxic materials, or other nonsoil materials.

E. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction and indicated on Drawings.

F. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction and [**indicated on Drawings**] [**indicated according to requirements in Section 015639 "Temporary Tree and Plant Protection."**] <**Insert requirement**>.

G. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

## 1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at [**Project site**] <**Insert location**>.

## 1.5 MATERIAL OWNERSHIP

A. Except for materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

## 1.6 INFORMATIONAL SUBMITTALS

A. 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.

1. Use sufficiently detailed photographs or video recordings.
2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plant designated to remain.

B. Topsoil stripping and stockpiling program.

C. Rock stockpiling program.

D. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

E. Burning: Documentation of compliance with burning requirements and permitting of authorities having jurisdiction. Identify location(s) and conditions under which burning will be performed.

## 1.7 QUALITY ASSURANCE

A. Topsoil Stripping and Stockpiling Program: Prepare a written program to systematically demonstrate the ability of personnel to properly follow procedures and handle materials and equipment during the Work. Include dimensioned diagrams for placement and protection of stockpiles.

B. Rock Stockpiling Program: Prepare a written program to systematically demonstrate the ability of personnel to properly follow procedures and handle materials and equipment during the Work. Include dimensioned diagrams for placement and protection of stockpiles.

## 1.8 FIELD CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed trafficways if required by Owner or authorities having jurisdiction.

B. Improvements on Adjoining Property: Authority for performing site clearing indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.

1. Do not proceed with work on adjoining property until directed by Architect.

C. Salvageable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises[ **where indicated**] <**Insert location**>.

D. Utility Locator Service: Notify [**utility locator service**] [**Miss Utility**] [**Call Before You Dig**] [**Dig Safe System**] [**One Call**] <**Insert name**> for area where Project is located before site clearing.

E. Do not commence site clearing operations until temporary erosion- and sedimentation-control[ **and plant-protection**] measures are in place.

F. Tree- and Plant-Protection Zones: Protect according to requirements in Section 015639 "Temporary Tree and Plant Protection."

G. Soil Stripping, Handling, and Stockpiling: Perform only when the soil is dry or slightly moist.

# PART 2 - PRODUCTS

## 2.1 MATERIALS

A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 312000 "Earth Moving."

1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

B. Antirust Coating: Fast-curing, lead- and chromate-free, self-curing, universal modified-alkyd primer complying with [**MPI #23 (surface-tolerant, anticorrosive metal primer)**] [**or**] [**SSPC-Paint 20 or SSPC-Paint 29 zinc-rich coating**] <**Insert requirement**>.

PART 3 - EXECUTION

## 3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Verify that trees, shrubs, and other vegetation to remain or to be relocated have been flagged and that protection zones have been identified and enclosed according to requirements in Section 015639 "Temporary Tree and Plant Protection."

C. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as acceptable to Owner.

## 3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. 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.

B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.

C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.

D. Remove erosion and sedimentation controls, and restore and stabilize areas disturbed during removal.

## 3.3 TREE AND PLANT PROTECTION

A. Protect trees and plants remaining on-site according to requirements in Section 015639 "Temporary Tree and Plant Protection."

B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations according to requirements in Section 015639 "Temporary Tree and Plant Protection."

## 3.4 EXISTING UTILITIES

A. Owner will arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing, when requested by Contractor.

1. Verify that utilities have been disconnected and capped before proceeding with site clearing.

B. Locate, identify, disconnect, and seal or cap utilities indicated to be removed[ **or abandoned in place**].

1. Arrange with utility companies to shut off indicated utilities.
2. Owner will arrange to shut off indicated utilities when requested by Contractor.

C. Locate, identify, and disconnect utilities indicated to be abandoned in place.

D. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others, unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect not less than [**two**] <**Insert number**> days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.

E. Excavate for and remove underground utilities indicated to be removed.

F. Removal of underground utilities is included in earthwork sections; in applicable fire suppression, plumbing, HVAC, electrical, communications, electronic safety and security, and utilities sections; and in Section 024116 "Structure Demolition" and Section 024119 "Selective Demolition."

## 3.5 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.

1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
2. Grind down stumps and remove roots larger than [**2 inches (50 mm)**] [**3 inches (75 mm)**] <**Insert dimension**> in diameter, obstructions, and debris to a depth of [**18 inches (450 mm)**] <**Insert dimension**> below exposed subgrade.
3. Use only hand methods or air spade for grubbing within protection zones.
4. Chip removed tree branches and [**stockpile in areas approved by Architect**] [**dispose of off-site**] <**Insert requirement**>.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

1. 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.

## 3.6 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to depth [**indicated on Drawings**] [**of 6 inches (150 mm)**] <**Insert requirement**> in a manner to prevent intermingling with underlying subsoil or other waste materials.

1. Remove subsoil and nonsoil materials from topsoil, including clay lumps, gravel, and other objects larger than 2 inches (50 mm) in diameter; trash, debris, weeds, roots, and other waste materials.

C. Stockpile topsoil away from edge of excavations without intermixing with subsoil or other materials. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.

1. Limit height of topsoil stockpiles to [**72 inches (1800 mm)**] <**Insert dimension**>.
2. Do not stockpile topsoil within protection zones.
3. Dispose of surplus topsoil. Surplus topsoil is that which exceeds quantity indicated to be stockpiled or reused.
4. Stockpile surplus topsoil to allow for respreading deeper topsoil.

## 3.7 STOCKPILING ROCK

A. Remove from [**area indicated on Drawings**] [**construction area**] <**Insert requirement**> naturally formed rocks that measure more than [**1 foot (300 mm)**] <**Insert dimension**> across in least dimension. Do not include excavated or crushed rock.

1. Separate or wash off non-rock materials from rocks, including soil, clay lumps, gravel, and other objects larger than 2 inches (50 mm) in diameter; trash, debris, weeds, roots, and other waste materials.

B. Stockpile rock [**where indicated on Drawings**] [**away from edge of excavations**] <**Insert requirement**> without intermixing with other materials. Cover to prevent windblown debris from accumulating among rocks.

1. Limit height of rock stockpiles to [**36 inches (900 mm)**] <**Insert dimension**>.
2. Do not stockpile rock within protection zones.
3. Dispose of surplus rock. Surplus rock is that which exceeds quantity indicated to be stockpiled or reused.
4. Stockpile surplus rock to allow later use by the Owner.

## 3.8 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.

1. 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.
2. 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.

## 3.9 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

B. Burning tree, shrub, and other vegetation waste is permitted according to burning requirements and permitting of authorities having jurisdiction. Control such burning to produce the least smoke or air pollutants and minimum annoyance to surrounding properties. Burning of other waste and debris is prohibited.

C. 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 10 00

# SECTION 31 20 00 - EARTH MOVING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. Section Includes:

1. Excavating and filling for rough grading the Site.
2. Preparing subgrades for slabs-on-grade, walks, pavements, turf and grasses and plants.
3. Excavating and backfilling for buildings and structures.
4. Drainage course for concrete slabs-on-grade.
5. Subbase course for concrete walks and pavements.
6. Subbase course and base course for asphalt paving.
7. Subsurface drainage backfill for walls and trenches.
8. Excavating and backfilling trenches for utilities and pits for buried utility structures.
9. Excavating well hole to accommodate elevator-cylinder assembly.

B. Related Requirements:

1. [**Section 013200 "Construction Progress Documentation"**] [**Section 013233 "Photographic Documentation"**] for recording preexcavation and earth-moving progress.
2. Section 033000 "Cast-in-Place Concrete" for granular course if placed over vapor retarder and beneath the slab-on-grade.
3. Section 311000 "Site Clearing" for site stripping, grubbing, stripping[ **and stockpiling**] topsoil, and removal of above- and below-grade improvements and utilities.
4. Section 312319 "Dewatering" for lowering and disposing of ground water during construction.
5. Section 315000 "Excavation Support and Protection" for shoring, bracing, and sheet piling of excavations.
6. Section 316329 "Drilled Concrete Piers and Shafts" for excavation of shafts and disposal of surplus excavated material.
7. Section 329200 "Turf and Grasses" for finish grading in turf and grass areas, including preparing and placing planting soil for turf areas.
8. Section 329300 "Plants" for finish grading in planting areas and tree and shrub pit excavation and planting.

1.3 UNIT PRICES

A. Work of this Section is affected by unit prices for earth moving specified in Section 012200 "Unit Prices."

B. Quantity allowances for earth moving are included in Section 012100 "Allowances."

C. Rock Measurement: Volume of rock actually removed, measured in original position, but not to exceed the following. Unit prices for rock excavation include replacement with approved materials.

1. [**24 inches (600 mm)**] <**Insert dimension**> outside of concrete forms other than at footings.
2. [**12 inches (300 mm)**] <**Insert dimension**> outside of concrete forms at footings.
3. [**6 inches (150 mm)**] <**Insert dimension**> 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)**] <**Insert dimension**> beneath bottom of concrete slabs-on-grade.
6. [**6 inches (150 mm)**] <**Insert dimension**> beneath pipe in trenches, and the greater of [**24 inches (600 mm)**] <**Insert dimension**> wider than pipe or [**42 inches (1065 mm)**] <**Insert dimension**> wide.

1.4 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions for [**unit prices**] [**changes in the Work**].
2. Bulk Excavation: Excavation more than [**10 feet (3 m)**] <**Insert dimension**> in width and more than [**30 feet (9 m)**] <**Insert dimension**> in length.

3. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.

G. Fill: Soil materials used to raise existing grades.

H. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed [**1 cu. yd. (0.76 cu. m)**] <**Insert volume**> for bulk excavation or [**3/4 cu. yd. (0.57 cu. m)**] <**Insert volume**> 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:

1. Equipment for Footing, Trench, and Pit Excavation: Late-model, track-mounted hydraulic excavator; equipped with a 42-inch- (1065-mm-) maximum-width, 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.
2. Equipment for 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.

I. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material [**3/4 cu. yd. (0.57 cu. m)**] <**Insert volume**> or more in volume that exceed a standard penetration resistance of [**100 blows/2 inches (97 blows/50 mm)**] <**Insert value**> when tested by a geotechnical testing agency, according to ASTM D 1586.

J. 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.

K. 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.

L. 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.

M. Utilities: On-site underground pipes, conduits, ducts, and cables as well as underground services within buildings.

## 1.5 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct preexcavation conference at [**Project site**] <**Insert location**>.

1. Review methods and procedures related to earthmoving, including, but not limited to, the following:

a. Personnel and equipment needed to make progress and avoid delays.
b. Coordination of Work with utility locator service.

c. Coordination of Work and equipment movement with the locations of tree- and plant-protection zones.
d. Extent of trenching by hand or with air spade.
e. Field quality control.
f. <**Insert agenda items**>.

## 1.6 ACTION SUBMITTALS

A. Product Data: For each type of the following manufactured products required:

1. Geotextiles.
2. Controlled low-strength material, including design mixture.
3. Geofoam.
4. Warning tapes.

B. Samples for Verification: For the following products, in sizes indicated below:

1. Geotextile: 12 by 12 inches (300 by 300 mm).
2. Warning Tape: 12 inches (300 mm) long; of each color.

## 1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Material Test Reports: For each [**on-site**] [**and**] [**borrow**] soil material proposed for fill and backfill as follows:

1. Classification according to ASTM D 2487.
2. Laboratory compaction curve according to [**ASTM D 698**] [**ASTM D 1557**].

C. Blasting plan[ **approved by authorities having jurisdiction**].

D. Seismic survey report from seismic survey agency.

E. Preexcavation 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.

## 1.8 QUALITY ASSURANCE

A. Blasting: 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.

B. Seismic Survey Agency: An independent testing agency, acceptable to authorities having jurisdiction, experienced in seismic surveys and blasting procedures to perform the following services:

1. 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.
2. Seismographic monitoring during blasting operations.

C. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.

## 1.9 FIELD CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth-moving operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Improvements on Adjoining Property: Authority for performing earth moving indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.

1. Do not proceed with work on adjoining property until directed by Architect.

C. Utility Locator Service: Notify [**utility locator service**] [**"Miss Utility"**] [**"Call Before You Dig"**] [**"Dig Safe System"**] [**"One Call"**] <**Insert name**> for area where Project is located before beginning earth-moving operations.

D. Do not commence earth-moving operations until temporary site fencing and erosion- and sedimentation-control measures specified in [**Section 015000 "Temporary Facilities and Controls"**] [**and**] [**Section 311000 "Site Clearing"**] are in place.

E. Do not commence earth-moving operations until plant-protection measures specified in Section 015639 "Temporary Tree and Plant Protection" are in place.

F. The following practices are prohibited within protection zones:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Foot traffic.
4. Erection of sheds or structures.
5. Impoundment of water.
6. Excavation or other digging unless otherwise indicated.
7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

G. Do not direct vehicle or equipment exhaust towards protection zones.

H. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

## PART 2 - PRODUCTS

### 2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: Soil Classification [**Groups GW, GP, GM, SW, SP, and SM according to ASTM D 2487**] [**Groups A-1, A-2-4, A-2-5, and A-3 according to AASHTO M 145**], or a combination of these groups; free of rock or gravel larger than [**3 inches (75 mm)**] <**Insert dimension**> in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

1. Liquid Limit: <**Insert value**>.
2. Plasticity Index: <**Insert value**>.

C. Unsatisfactory Soils: Soil Classification [**Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487**] [**Groups A-2-6, A-2-7, A-4, A-5, A-6, and A-7 according to AASHTO M 145**], or a combination of these groups.

1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

D. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; 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.

E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 294/D 2940M 0; 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.

F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; 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.

G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; 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.

H. Drainage Course: Narrowly graded mixture of [**washed** ]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 zero to 5 percent passing a No. 8 (2.36-mm) sieve.

I. 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 zero to 5 percent passing a No. 4 (4.75-mm) sieve.

J. Sand: ASTM C 33/C 33M; fine aggregate.

K. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

## 2.2 GEOTEXTILES

A. 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:

1. Survivability: Class 2; AASHTO M 288.
2. Survivability: As follows:

    a. Grab Tensile Strength: 157 lbf (700 N); ASTM D 4632.
    b. Sewn Seam Strength: 142 lbf (630 N); ASTM D 4632.
    c. Tear Strength: 56 lbf (250 N); ASTM D 4533.
    d. Puncture Strength: 56 lbf (250 N); ASTM D 4833.

3. Apparent Opening Size: [**No. 40 (0.425-mm)**] [**No. 60 (0.250-mm)**] [**No. 70 (0.212-mm)**] sieve, maximum; ASTM D 4751.
4. Permittivity: [**0.5**] [**0.2**] [**0.1**] per second, minimum; ASTM D 4491.
5. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

B. 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:

1. Survivability: Class 2; AASHTO M 288.
2. Survivability: As follows:

    a. Grab Tensile Strength: 247 lbf (1100 N); ASTM D 4632.
    b. Sewn Seam Strength: 222 lbf (990 N); ASTM D 4632.
    c. Tear Strength: 90 lbf (400 N); ASTM D 4533.
    d. Puncture Strength: 90 lbf (400 N); ASTM D 4833.

3. Apparent Opening Size: No. 60 (0.250-mm) sieve, maximum; ASTM D 4751.
4. Permittivity: 0.02 per second, minimum; ASTM D 4491.
5. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

## 2.3 CONTROLLED LOW-STRENGTH MATERIAL

A. Controlled Low-Strength Material: Self-compacting[**, low-density**], flowable concrete material produced from the following:

1. Portland Cement: ASTM C 150/C 150M, [**Type I**] [**Type II**] [**or**] [**Type III**].
2. Fly Ash: ASTM C 618, Class C or F.
3. Normal-Weight Aggregate: ASTM C 33/C 33M, [**3/4-inch (19-mm)**] [**3/8-inch (10-mm)**] <**Insert dimension**> nominal maximum aggregate size.

4. Foaming Agent: ASTM C 869/C 869M.
5. Water: ASTM C 94/C 94M.
6. Air-Entraining Admixture: ASTM C 260/C 260M.

B. Produce low-density, controlled low-strength material with the following physical properties:

1. As-Cast Unit Weight: [**30 to 36 lb/cu. ft. (480 to 576 kg/cu. m)**] [**36 to 42 lb/cu. ft. (576 to 675 kg/cu. m)**] <**Insert unit weight range**> at point of placement, when tested according to ASTM C 138/C 138M.
2. Compressive Strength: [**80 psi (550 kPa)**] [**140 psi (965 kPa)**] <**Insert value**>, when tested according to ASTM C 495/C 495M.

C. Produce conventional-weight, controlled low-strength material with [**80-psi (550-kPa)**] [**140-psi (965-kPa)**] <**Insert value**> compressive strength when tested according to ASTM C 495/C 495M.

## 2.4 GEOFOAM

A. 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**] [**Type X, 1.30-lb/cu. ft. (21-kg/cu. m) density, 15-psi (104-kPa) compressive strength**] [**Type VI, 1.80-lb/cu. ft. (29-kg/cu. m) density, 40-psi (276-kPa) compressive strength**] [**Type VII, 2.20-lb/cu. ft. (35-kg/cu. m) density, 60-psi (414-kPa) compressive strength**] [**Type V, 3.00-lb/cu. ft. (48-kg/cu. m) density, 100-psi (690-kPa) compressive strength**].

B. 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**] [**Type VIII, 1.15-lb/cu. ft. (18-kg/cu. m) density, 13-psi (90-kPa) compressive strength**] [**Type II, 1.35-lb/cu. ft. (22-kg/cu. m) density, 15-psi (104-kPa) compressive strength**].

1. Manufacture molded polystyrene with an inorganic mineral registered with the EPA and suitable for application as a termite deterrent.

C. 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**] [**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**] <**Insert requirement**>.

D. Connectors: [**Geofoam manufacturer's multibarbed, galvanized-steel sheet connectors**] [**Deformed steel reinforcing bars, 3/4 inch (19 mm) in diameter**] <**Insert requirement**>.

## 2.5 ACCESSORIES

A. 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:

1. Red: Electric.

2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

B. 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:

1. Red: Electric.
2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. 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.

B. Protect and maintain erosion and sedimentation controls during earth-moving operations.

C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

### 3.2 DEWATERING

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

B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. 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.

### 3.3 EXPLOSIVES

A. Explosives: Do not use explosives.

B. Explosives: Obtain written permission from authorities having jurisdiction before bringing explosives to Project site or using explosives on Project site.

1. Perform blasting without damaging adjacent structures, property, or site improvements.
2. Perform blasting without weakening the bearing capacity of rock subgrade and with the least-practicable disturbance to rock to remain.

## 3.4 EXCAVATION, GENERAL

A. 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.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
2. Remove rock to lines and grades indicated to permit installation of permanent construction without exceeding the following dimensions:

    a. [**24 inches (600 mm)**] <**Insert dimension**> outside of concrete forms other than at footings.
    b. [**12 inches (300 mm)**] <**Insert dimension**> outside of concrete forms at footings.
    c. [**6 inches (150 mm)**] <**Insert dimension**> outside of minimum required dimensions of concrete cast against grade.
    d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
    e. [**6 inches (150 mm)**] <**Insert dimension**> beneath bottom of concrete slabs-on-grade.
    f. [**6 inches (150 mm)**] <**Insert dimension**> beneath pipe in trenches and the greater of [**24 inches (600 mm)**] <**Insert dimension**> wider than pipe or [**42 inches (1065 mm)**] <**Insert dimension**> wide.

B. 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 Architect. 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.

1. Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and other items indicated to be removed; and soil, boulders, and other materials not classified as rock or unauthorized excavation.

    a. Intermittent drilling; blasting, if permitted; ram hammering; or ripping of material not classified as rock excavation is earth excavation.

2. 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:

    a. [**24 inches (600 mm)**] <**Insert dimension**> outside of concrete forms other than at footings.
    b. [**12 inches (300 mm)**] <**Insert dimension**> outside of concrete forms at footings.

c. [**6 inches (150 mm)**] <**Insert dimension**> outside of minimum required dimensions of concrete cast against grade.
d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
e. [**6 inches (150 mm)**] <**Insert dimension**> beneath bottom of concrete slabs-on-grade.
f. [**6 inches (150 mm)**] <**Insert dimension**> beneath pipe in trenches and the greater of [**24 inches (600 mm)**] <**Insert dimension**> wider than pipe or [**42 inches (1065 mm)**] <**Insert dimension**> wide.

## 3.5 EXCAVATION FOR STRUCTURES

A. 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.

1. 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.
2. 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.
3. 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.

B. Excavations at Edges of Tree- and Plant-Protection Zones:

1. Excavate by hand or with an air spade to indicated lines, cross sections, elevations, and subgrades. If excavating by hand, 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.
2. Cut and protect roots according to requirements in Section 015639 "Temporary Tree and Plant Protection."

## 3.6 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

## 3.7 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

B. 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.

1. Clearance: [**12 inches (300 mm) each side of pipe or conduit**] [**As indicated**].

C. Trench Bottoms: 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.

1. 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.
2. 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.
3. For flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support conduit on an undisturbed subgrade.
4. Excavate trenches 6 inches (150 mm) deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

D. Trench Bottoms: 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.

1. Excavate trenches 6 inches (150 mm) deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

E. Trenches in Tree- and Plant-Protection Zones:

1. 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.
2. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.
3. Cut and protect roots according to requirements in Section 015639 "Temporary Tree and Plant Protection."

## 3.8 EXCAVATION FOR ELEVATOR CYLINDER

A. Drill well hole plumb in elevator pit to accommodate installation of elevator-cylinder assembly. Coordinate with applicable requirements for diameter and tolerances in [**Section 142400 "Hydraulic Elevators."**] [**Section 142413 "Hydraulic Freight Elevators."**]

B. Provide well casing as necessary to retain walls of well hole.

## 3.9 SUBGRADE INSPECTION

A. Notify Architect when excavations have reached required subgrade.

B. If Architect determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

C. Proof-roll subgrade [**below the building slabs and pavements**] <**Insert locations**> with a pneumatic-tired [**and loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons (13.6 tonnes)**] <**Insert requirement**> to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. 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).
2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

D. Authorized additional excavation and replacement material will be paid for according to Contract provisions for [**unit prices**] [**changes in the Work**].

E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

## 3.10 UNAUTHORIZED EXCAVATION

A. 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 Architect.

1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Architect.

## 3.11 STORAGE OF SOIL MATERIALS

A. 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.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

## 3.12 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
2. Surveying locations of underground utilities for Record Documents.
3. Testing and inspecting underground utilities.
4. Removing concrete formwork.
5. Removing trash and debris.
6. Removing temporary shoring, bracing, and sheeting.

7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

B. Place backfill on subgrades free of mud, frost, snow, or ice.

## 3.13 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. 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.

C. Trenches under Footings: Backfill trenches excavated under footings and within [**18 inches (450 mm)**] <**Insert dimension**> of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**]

D. Trenches under Roadways: Provide [**4-inch- (100-mm-)**] <**Insert dimension**> thick, concrete-base slab support for piping or conduit less than [**30 inches (750 mm)**] <**Insert dimension**> below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of [**4 inches (100 mm)**] <**Insert dimension**> of concrete before backfilling or placing roadway subbase course. Concrete is specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**]

E. Backfill voids with satisfactory soil while removing shoring and bracing.

F. Initial Backfill:

1. Soil Backfill: Place and compact initial backfill of [**subbase material**] [**satisfactory soil**], free of particles larger than [**1 inch (25 mm)**] <**Insert dimension**> 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.

2. Controlled Low-Strength Material: 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.

G. Final Backfill:

1. Soil Backfill: Place and compact final backfill of satisfactory soil to final subgrade elevation.
2. Controlled Low-Strength Material: Place final backfill of controlled low-strength material to final subgrade elevation.

H. Warning Tape: Install warning tape directly above utilities, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

## 3.14 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers to required elevations as follows:

1. Under grass and planted areas, use satisfactory soil material.
2. Under walks and pavements, use satisfactory soil material.
3. Under steps and ramps, use engineered fill.
4. Under building slabs, use engineered fill.
5. Under footings and foundations, use engineered fill.

C. Place soil fill on subgrades free of mud, frost, snow, or ice.

## 3.15 GEOFOAM FILL

A. Place a leveling course of sand, [**2 inches (50 mm)**] <**Insert dimension**> thick, over subgrade. Finish leveling course to a tolerance of 1/2 inch (13 mm) when tested with a 10-foot (3-m) straightedge.

1. 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.

D. Cover geofoam with [**subdrainage**] [**separation**] geotextile before placing overlying soil materials.

## 3.16 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
2. 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.

## 3.17 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than [**8 inches (200 mm)**] <**Insert dimension**> 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.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations and uniformly along the full length of each structure.

C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to [**ASTM D 698**] [**ASTM D 1557**]:

1. 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**] <**Insert number**> percent.
2. Under walkways, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill soil material at [**92**] <**Insert number**> percent.
3. 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**] <**Insert number**> percent.
4. For utility trenches, compact each layer of initial and final backfill soil material at [**85**] <**Insert number**> percent.

## 3.18 GRADING

A. 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.

1. Provide a smooth transition between adjacent existing grades and new grades.
2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to elevations required to achieve indicated finish elevations, within the following subgrade tolerances:

1. Turf or Unpaved Areas: Plus or minus [**1 inch (25 mm)**] <**Insert dimension**>.
2. Walks: Plus or minus [**1 inch (25 mm)**] <**Insert dimension**>.
3. Pavements: Plus or minus [**1/2 inch (13 mm)**] <**Insert dimension**>.

C. Grading inside Building Lines: Finish subgrade to a tolerance of [**1/2 inch (13 mm)**] <**Insert dimension**> when tested with a 10-foot (3-m) straightedge.

## 3.19 SUBSURFACE DRAINAGE

A. Subdrainage Pipe: Specified in Section 334600 "Subdrainage."

B. Subsurface Drain: 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).

1. Compact each filter material layer [**to 85 percent of maximum dry unit weight according to ASTM D 698**] [**with a minimum of two passes of a plate-type vibratory compactor**].

C. Drainage Backfill: 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).

1. Compact each filter material layer [**to 85 percent of maximum dry unit weight according to ASTM D 698**] [**with a minimum of two passes of a plate-type vibratory compactor**].
2. Place and compact impervious fill over drainage backfill in 6-inch- (150-mm-) thick compacted layers to final subgrade.

## 3.20 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

A. Place subbase course[ **and base course**] on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place subbase course[ **and base course**] under pavements and walks as follows:

1. Install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
2. Place base course material over subbase course under hot-mix asphalt pavement.
3. Shape subbase course[ **and base course**] to required crown elevations and cross-slope grades.
4. Place subbase course[ **and base course**] 6 inches (150 mm) or less in compacted thickness in a single layer.
5. Place subbase course[ **and base 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.
6. Compact subbase course[ **and base course**] at optimum moisture content to required grades, lines, cross sections, and thickness to not less than [**95**] <**Insert number**> percent of maximum dry unit weight according to [**ASTM D 698**] [**ASTM D 1557**].

C. Pavement Shoulders: Place shoulders along edges of subbase course[ **and base course**] 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**] layer to not less than [**95**] <**Insert number**> percent of maximum dry unit weight according to [**ASTM D 698**] [**ASTM D 1557**].

## 3.21 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-GRADE

A. Place drainage course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:

1. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
2. Place drainage course 6 inches (150 mm) or less in compacted thickness in a single layer.
3. 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.
4. Compact each layer of drainage course to required cross sections and thicknesses to not less than [**95**] <**Insert number**> percent of maximum dry unit weight according to ASTM D 698.

## 3.22 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:

1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
2. Determine that fill material classification and maximum lift thickness comply with requirements.
3. Determine, during placement and compaction, that in-place density of compacted fill complies with requirements.
4. <**Insert special inspections**>.

B. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

C. 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.

D. 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 Architect.

E. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2937, and ASTM D 6938, as applicable. Tests will be performed at the following locations and frequencies:

1. 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)**] <**Insert area**> or less of paved area or building slab but in no case fewer than three tests.
2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every [**100 feet (30 m)**] <**Insert dimension**> or less of wall length but no fewer than two tests.
3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every [**150 feet (46 m)**] <**Insert dimension**> or less of trench length but no fewer than two tests.

F. 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.

## 3.23 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. 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.

1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

## 3.24 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

B. Transport surplus satisfactory soil to designated storage areas on Owner's property. Stockpile or spread soil as directed by Architect.

1. Remove waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 31 20 00

# SECTION 31 50 00 - EXCAVATION SUPPORT AND PROTECTION

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. Section includes temporary excavation support and protection systems.

B. Related Requirements:

1. Section 013233 "Photographic Documentation" for recording preexisting conditions and excavation support and protection system progress.
2. Section 312000 "Earth Moving" for excavating and backfilling and for controlling surface-water runoff and ponding.
3. Section 312319 "Dewatering" for dewatering excavations.

### 1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at [**Project site**] <**Insert location**>.

1. Review geotechnical report.
2. Review existing utilities and subsurface conditions.
3. Review coordination for interruption, shutoff, capping, and continuation of utility services.
4. Review proposed excavations.
5. Review proposed equipment.
6. Review monitoring of excavation support and protection system.
7. Review coordination with waterproofing.
8. Review abandonment or removal of excavation support and protection system.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, performance properties, and dimensions of individual components and profiles, and calculations for excavation support and protection system.

B. Shop Drawings: For excavation support and protection system, prepared by or under the supervision of a qualified professional engineer.

1. Include plans, elevations, sections, and details.
2. Show arrangement, locations, and details of soldier piles, piling, lagging, tiebacks, bracing, and other components of excavation support and protection system according to engineering design.
3. Indicate type and location of waterproofing.
4. Include a written plan for excavation support and protection, including sequence of construction of support and protection coordinated with progress of excavation.

## 1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For [**land surveyor**] [**and**] [**professional engineer**].

B. Contractor Calculations: For excavation support and protection system. Include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Existing Conditions: Using [**photographs**] [**or**] [**video recordings**], show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by inadequate performance of excavation support and protection systems. Submit before Work begins.

D. Record Drawings: Identify locations and depths of capped utilities, abandoned-in-place support and protection systems, and other subsurface structural, electrical, or mechanical conditions.

## 1.6 FIELD CONDITIONS

A. Interruption of Existing Utilities: Do not interrupt any utility serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:

1. Notify [**Architect**] [**Construction Manager**] [**Owner**] no fewer than [**two**] <**Insert number**> days in advance of proposed interruption of utility.
2. Do not proceed with interruption of utility without [**Architect's**] [**Construction Manager's**] [**Owner's**] written permission.

B. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of a geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by a geotechnical engineer. Owner is not responsible for interpretations or conclusions drawn from the data.

1. Make additional test borings and conduct other exploratory operations necessary for excavation support and protection according to the performance requirements.
2. The geotechnical report is [**included**] [**referenced**] elsewhere in Project Manual.

C. 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.

PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

A. Provide,[ **design,**] monitor, and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting earth and hydrostatic pressures and superimposed and construction loads.

1. Contractor Design: Design excavation support and protection system, including comprehensive engineering analysis by a qualified professional engineer.
2. Prevent surface water from entering excavations by grading, dikes, or other means.
3. Install excavation support and protection systems without damaging existing buildings, structures, and site improvements adjacent to excavation.
4. Continuously monitor vibrations, settlements, and movements to ensure stability of excavations and constructed slopes and to ensure that damage to permanent structures is prevented.

## 2.2 MATERIALS

A. General: Provide materials that are either new or in serviceable condition.

B. Structural Steel: ASTM A 36/A 36M, ASTM A 690/A 690M, or ASTM A 992/A 992M.

C. Steel Sheet Piling: ASTM A 328/A 328M, ASTM A 572/A 572M, or ASTM A 690/A 690M; with continuous interlocks.

1. Corners: [**Site-fabricated mechanical interlock**] [**Roll-formed corner shape with continuous interlock**].

D. Wood Lagging: Lumber, mixed hardwood, nominal rough thickness of [**size and strength required for application**] [**3 inches (75 mm)**] [**4 inches (100 mm)**] <**Insert dimension**>.

E. Shotcrete: Comply with Section 033713 "Shotcrete" for shotcrete materials and mixes, reinforcement, and shotcrete application.

F. Cast-in-Place Concrete: ACI 301, of compressive strength required for application.

G. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.

H. Tiebacks: Steel bars, ASTM A 722/A 722M.

I. Tiebacks: Steel strand, ASTM A 416/A 416M.

PART 3 - EXECUTION

## 3.1 PREPARATION

A. 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.

1. Shore, support, and protect utilities encountered.

B. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

C. Locate excavation support and protection systems clear of permanent construction so that construction and finishing of other work is not impeded.

## 3.2 SOLDIER PILES AND LAGGING

A. 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**] <**Insert tolerances**>.

B. 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.

C. Install wales horizontally at locations indicated on Drawings and secure to soldier piles.

## 3.3 SHEET PILING

A. Before starting excavation, install one-piece sheet piling lengths and tightly interlock vertical edges to form a continuous barrier.

B. 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**] <**Insert tolerances**>.

C. Cut tops of sheet piling to uniform elevation at top of excavation.

## 3.4 TIEBACKS

A. Drill, install, grout, and tension tiebacks.

B. Test load-carrying capacity of each tieback and replace and retest deficient tiebacks.

1. Have test loading observed by a qualified professional engineer responsible for design of excavation support and protection system.

C. Maintain tiebacks in place until permanent construction is able to withstand lateral earth and hydrostatic pressures.

## 3.5 BRACING

A. 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.

1. Do not place bracing where it will be cast into or included in permanent concrete work unless otherwise approved by Architect.
2. Install internal bracing if required to prevent spreading or distortion of braced frames.
3. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

## 3.6 FIELD QUALITY CONTROL

A. Survey-Work Benchmarks: Resurvey benchmarks [**regularly**] [**daily**] [**weekly**] <**Insert time period**> during installation of excavation support and protection systems, excavation progress, and for as long as excavation remains open. Maintain an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify Architect if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

B. Promptly correct detected bulges, breakage, or other evidence of movement to ensure that excavation support and protection system remains stable.

C. Promptly repair damages to adjacent facilities caused by installation or faulty performance of excavation support and protection systems.

## 3.7 REMOVAL AND REPAIRS

A. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and earth and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils and rock or damaging structures, pavements, facilities, and utilities.

1. Remove excavation support and protection systems to a minimum depth of 48 inches (1200 mm) below overlying construction and abandon remainder.

2. Fill voids immediately with approved backfill compacted to density specified in Section 312000 "Earth Moving."
3. Repair or replace, as approved by Architect, adjacent work damaged or displaced by removing excavation support and protection systems.

B. Leave excavation support and protection systems permanently in place.

END OF SECTION 31 50 00

# SECTION 32 12 16 - ASPHALT PAVING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. Section Includes:

1. Cold milling of existing asphalt pavement.
2. Hot-mix asphalt patching.
3. Hot-mix asphalt paving.
4. Hot-mix asphalt overlay.
5. Asphalt curbs.
6. Asphalt traffic-calming devices.
7. Asphalt surface treatments.

B. Related Requirements:

1. Section 024116 "Structure Demolition” for demolition and removal of existing asphalt pavement.
2. Section 312000 "Earth Moving" for subgrade preparation, fill material, unbound-aggregate subbase and base courses, and aggregate pavement shoulders.
3. Section 321373 "Concrete Paving Joint Sealants" for joint sealants and fillers at pavement terminations.
4. Section 321400 "Unit Paving" for bituminous setting bed for pavers.

### 1.3 UNIT PRICES

A. Work of this Section is affected by <**Insert name of unit price**>.

### 1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at [**Project site**] <**Insert location**>.

1. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:

a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
b. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include technical data and tested physical and performance properties.
2. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.
3. Job-Mix Designs: For each job mix proposed for the Work.

B. Sustainable Design Submittals:

1. <Double click to insert sustainable design text for recycled content.>

C. Samples for Verification: For the following product, in manufacturer's standard sizes unless otherwise indicated:

1. Paving Fabric: 12 by 12 inches (300 by 300 mm) minimum.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For [**manufacturer**] [**and**] [**testing agency**].

B. Material Certificates: For each paving material.[ **Include statement that mixes containing recycled materials will perform equal to mixes produced from all new materials.**]

C. Material Test Reports: For each paving material, by a qualified testing agency.

D. Field quality-control reports.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications: [**A paving-mix manufacturer registered with and approved by authorities having jurisdiction or the DOT of state in which Project is located**] <**Insert requirement**>.

B. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.

C. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of <**Insert applicable standards**> of <**Insert name of state or local DOT**> for asphalt paving work.

1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

1.8 FIELD CONDITIONS

A. 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:

1. Prime Coat: Minimum surface temperature of 60 deg F (15.6 deg C).
2. Tack Coat: Minimum surface temperature of 60 deg F (15.6 deg C).
3. Slurry Coat: Comply with weather limitations in ASTM D 3910.
4. Asphalt Base Course: Minimum surface temperature of 40 deg F (4.4 deg C) and rising at time of placement.
5. Asphalt Surface Course: Minimum surface temperature of 60 deg F (15.6 deg C) at time of placement.

## PART 2 - PRODUCTS

### 2.1 AGGREGATES

A. General: Use materials and gradations that have performed satisfactorily in previous installations.

B. Coarse Aggregate: ASTM D 692/D 692M, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.

C. 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.

1. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.

D. Mineral Filler: [**ASTM D 242/D 242M**] [**or**] [**AASHTO M 17**], rock or slag dust, hydraulic cement, or other inert material.

### 2.2 ASPHALT MATERIALS

A. Asphalt Binder: AASHTO M 320, [**PG 64-22**] [**PG 58-28**] [**PG 70-22**] <**Insert performance grade**>.

B. Asphalt Cement: [**ASTM D 3381/D 3381M for viscosity-graded material**] [**ASTM D 946/D 946M for penetration-graded material**].

C. Cutback Prime Coat: ASTM D 2027, medium-curing cutback asphalt, [**MC-30 or MC-70**] [**MC-250**].

D. Emulsified Asphalt Prime 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.

E. 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.

F. 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.

G. Water: Potable.

H. Undersealing Asphalt: ASTM D 3141/D 3141M; pumping consistency.

## 2.3 AUXILIARY MATERIALS

A. Recycled Materials for Hot-Mix Asphalt Mixes: Reclaimed asphalt pavement; reclaimed, unbound-aggregate base material; and recycled [**tires**] [**asphalt shingles**] [**or**] [**glass**] from sources and gradations that have performed satisfactorily in previous installations, equal to performance of required hot-mix asphalt paving produced from all new materials.

B. Herbicide: Commercial chemical for weed control, registered by the EPA, and not classified as "restricted use" for locations and conditions of application. Provide in granular, liquid, or wettable powder form.

C. Sand: [**ASTM D 1073**] [**or**] [**AASHTO M 29**], Grade No. 2 or No. 3.

D. Paving Geotextile: AASHTO M 288 paving fabric; nonwoven polypropylene; resistant to chemical attack, rot, and mildew; and specifically designed for paving applications.

E. Joint Sealant: [**ASTM D 6690**] [**or**] [**AASHTO M 324**], [**Type I**] [**Type II or III**] [**Type IV**], hot-applied, single-component, polymer-modified bituminous sealant.

## 2.4 MIXES

A. <Double click to insert sustainable design text for recycled content.>

1. Surface Course Limit: Recycled content no more than [**10**] <**Insert number**> percent by weight.

B. Hot-Mix Asphalt: Dense-graded, 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:

1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
2. Base Course: <**Insert mix designation**>.
3. Surface Course: <**Insert mix designation**>.

C. Emulsified-Asphalt Slurry: ASTM D 3910, [**Type 1**] [**Type 2**] [**Type 3**].

PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to begin paving.

B. 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.

1. 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).
2. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons (13.6 tonnes).
3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

C. Proceed with paving only after unsatisfactory conditions have been corrected.

## 3.2 COLD MILLING

A. 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.

1. Mill to a depth of [**1-1/2 inches (38 mm)**] [**2 inches (50 mm)**] [**3 inches (75 mm)**] <**Insert dimension**>.
2. Mill to a uniform finished surface free of excessive gouges, grooves, and ridges.
3. Control rate of milling to prevent tearing of existing asphalt course.
4. Repair or replace curbs, manholes, and other construction damaged during cold milling.
5. Excavate and trim unbound-aggregate base course, if encountered, and keep material separate from milled hot-mix asphalt.
6. Patch surface depressions deeper than 1 inch (25 mm) after milling, before wearing course is laid.
7. Handle milled asphalt material according to approved waste management plan required in Section 017419 "Construction Waste Management and Disposal."
8. Keep milled pavement surface free of loose material and dust.
9. Do not allow milled materials to accumulate on-site.

## 3.3 PATCHING

A. 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 perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. Portland Cement Concrete Pavement: Break cracked slabs and roll as required to reseat concrete pieces firmly.

1. Pump hot undersealing asphalt under rocking slab until slab is stabilized or, if necessary, crack slab into pieces and roll to reseat pieces firmly.
2. Remove disintegrated or badly cracked pavement. Excavate rectangular or trapezoidal patches, extending into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Recompact existing unbound-aggregate base course to form new subgrade.

C. Tack Coat: Before placing patch material, apply tack coat uniformly to vertical asphalt surfaces abutting the patch. Apply at a rate of 0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m).

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

D. Placing Patch Material: Fill excavated pavement areas with hot-mix asphalt base mix for full thickness of patch and, while still hot, compact flush with adjacent surface.

E. Placing Patch Material: 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.

## 3.4 REPAIRS

A. 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.

1. Install leveling wedges in compacted lifts not exceeding 3 inches (75 mm) thick.

B. Crack and Joint Filling: Remove existing joint filler material from cracks or joints to a depth of [**1/4 inch (6 mm)**] <**Insert dimension**>.

1. Clean cracks and joints in existing hot-mix asphalt pavement.
2. 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.
3. 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.

## 3.5 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

B. 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.

1. Mix herbicide with prime coat if formulated by manufacturer for that purpose.

C. Cutback 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.

1. 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.
2. Protect primed substrate from damage until ready to receive paving.

D. Emulsified Asphalt Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of 0.10 to 0.30 gal./sq. yd. per inch depth (0.5 to 1.40 L/sq. m per 25 mm depth). Apply enough material to penetrate and seal, but not flood, surface. Allow prime coat to cure.

1. 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.
2. Protect primed substrate from damage until ready to receive paving.

E. 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).

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

## 3.6 PAVING GEOTEXTILE INSTALLATION

A. Apply [**tack coat**] [**asphalt binder**] [**asphalt cement**] 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).

B. 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).

C. Protect paving geotextile from traffic and other damage, and place hot-mix asphalt overlay the same day.

## 3.7 PLACING HOT-MIX ASPHALT

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand in areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.

1. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
2. Place hot-mix asphalt surface course in single lift.
3. Spread mix at a minimum temperature of 250 deg F (121 deg C).
4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.

5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

B. Place paving in consecutive strips not less than 10 feet (3 m) wide unless infill edge strips of a lesser width are required.

1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Overlap mix placement about 1 to 1-1/2 inches (25 to 38 mm) from strip to strip to ensure proper compaction of mix along longitudinal joints.
2. Complete a section of asphalt base course before placing asphalt surface course.

C. 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.

## 3.8 JOINTS

A. 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.

1. Clean contact surfaces and apply tack coat to joints.
2. Offset longitudinal joints, in successive courses, a minimum of 6 inches (150 mm).
3. Offset transverse joints, in successive courses, a minimum of 24 inches (600 mm).
4. 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."**] [**as shown on Drawings.**] <**Insert joint requirement.**>
5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
6. Compact asphalt at joints to a density within 2 percent of specified course density.

## 3.9 COMPACTION

A. 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.

1. Complete compaction before mix temperature cools to 185 deg F (85 deg C).

B. 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.

C. 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:

1. Average Density: 96 percent of reference laboratory density according to [**ASTM D 6927**] [**or**] [**AASHTO T 245**], but not less than 94 percent or greater than 100 percent.
2. Average Density: 92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent or greater than 96 percent.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. 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.

F. 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.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

## 3.10 ASPHALT CURBS

A. 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 a minimum temperature of 250 deg F (121 deg C).

1. Asphalt Mix: Same as pavement surface-course mix.

B. 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.

## 3.11 ASPHALT TRAFFIC-CALMING DEVICES

A. 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 a minimum temperature of 250 deg F (121 deg C).

1. 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.)
2. Asphalt Mix: Same as pavement surface-course mix.
3. 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.

B. Place and compact 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.

## 3.12 INSTALLATION TOLERANCES

A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:

1. Base Course: Plus or minus 1/2 inch (13 mm).
2. Surface Course: Plus 1/4 inch (6 mm), no minus.

B. 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:

1. Base Course: [**1/4 inch (6 mm)**] <**Insert dimension**>.
2. Surface Course: [**1/8 inch (3 mm)**] <**Insert dimension**>.
3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch (6 mm).

C. Asphalt 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.

## 3.13 SURFACE TREATMENTS

A. 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.

B. Slurry Seals: Apply slurry coat in a uniform thickness according to ASTM D 3910 and allow to cure.

1. Roll slurry seal to remove ridges and provide a uniform, smooth surface.

## 3.14 FIELD QUALITY CONTROL

A. Testing Agency: [**Owner will engage**] [**Engage**] a qualified testing agency to perform tests and inspections.

B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.

C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.

D. Asphalt Traffic-Calming Devices: Finished height of traffic-calming devices above pavement will be measured for compliance with tolerances.

E. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to [**ASTM D 979**] [**or**] [**AASHTO T 168**].

1. 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.
2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.

    a. One core sample will be taken for every 1000 sq. yd. (836 sq. m) or less of installed pavement, with no fewer than three cores taken.
    b. 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.

F. Replace and compact hot-mix asphalt where core tests were taken.

G. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

## 3.15 WASTE HANDLING

A. General: Handle asphalt-paving waste according to approved waste management plan required in Section 017419 "Construction Waste Management and Disposal."

END OF SECTION 32 12 16

# SECTION 32 13 13 - CONCRETE PAVING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. Section Includes Concrete Paving for:

1. Driveways.
2. Roadways.
3. Curbs and gutters.
4. Walks.

B. Related Requirements:

1. Section 033000 "Cast-in-Place Concrete" for general building applications of concrete.
2. Section 321316 "Decorative Concrete Paving" for stamped concrete other than stamped detectable warnings.
3. Section 321373 "Concrete Paving Joint Sealants" for joint sealants in expansion and contraction joints within concrete paving and in joints between concrete paving and asphalt paving or adjacent construction.
4. Section 321713 "Parking Bumpers."
5. Section 321723 "Pavement Markings."
6. Section 321726 "Tactile Warning Surfacing" for detectable warning tiles and pavers.
7. Section 321729 "Manufactured Traffic-Calming Devices."

### 1.3 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash, slag cement, and other pozzolans.

B. W/C Ratio: The ratio by weight of water to cementitious materials.

### 1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at [**Project site**] <**Insert location**>.

1. Review methods and procedures related to concrete paving, including but not limited to, the following:

a. Concrete mixture design.

b. Quality control of concrete materials and concrete paving construction practices.
c. <**Insert agenda item**>.

2. Require representatives of each entity directly concerned with concrete paving to attend, including the following:

a. Contractor's superintendent.
b. Independent testing agency responsible for concrete design mixtures.
c. Ready-mix concrete manufacturer.
d. Concrete paving Subcontractor.
e. Manufacturer's representative of stamped concrete paving system used for stamped detectable warnings.

## 1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. <Double click to insert sustainable design text for recycled content.>
2. <Double click to insert sustainable design text for regional materials.>
3. <Double click to insert sustainable design text for solar reflectance.>

C. Samples for Initial Selection: For each type of product, ingredient, or admixture requiring color selection.

D. Samples for Verification: For each type of product or exposed finish, prepared as Samples of size indicated below:

1. Exposed Aggregate: [**10-lb (4.5-kg)**] <**Insert weight**> Sample of each mix.

E. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

## 1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified [**Installer of stamped detectable warnings**] [**ready-mix concrete manufacturer**] [**and**] [**testing agency**].

B. Material Certificates: For the following, from manufacturer:

1. Cementitious materials.
2. Steel reinforcement and reinforcement accessories.
3. Fiber reinforcement.
4. Admixtures.
5. Curing compounds.
6. Applied finish materials.
7. Bonding agent or epoxy adhesive.

8. Joint fillers.

C. Material Test Reports: For each of the following:

1. Aggregates:[ **Include service-record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.**]

D. Field quality-control reports.

## 1.7 QUALITY ASSURANCE

A. Stamped Detectable Warning Installer Qualifications: An employer of workers trained and approved by manufacturer of stamped concrete paving systems.

B. 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.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual - Section 3, "Plant Certification Checklist").

C. Testing Agency Qualifications: Qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.

1. 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.

D. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Build mockups of full-thickness sections of concrete paving to demonstrate typical joints; surface finish, texture, and color; curing; and standard of workmanship.
2. Build mockups of concrete paving in the location and of the size indicated or, if not indicated, build mockups where directed by Architect and not less than [**96 inches (2400 mm) by 96 inches (2400 mm)**] <**Insert dimensions**>.[ **Include full-size detectable warning.**]
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

## 1.8 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified independent testing agency to perform preconstruction testing on concrete paving mixtures.

1.9 FIELD CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

B. Cold-Weather Concrete 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:

1. 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.
2. Do not use frozen materials or materials containing ice or snow.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.

C. Hot-Weather Concrete Placement: Comply with ACI 301 (ACI 301M) and as follows when hot-weather conditions exist:

1. 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.
2. Cover steel reinforcement with water-soaked burlap, so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
3. Fog-spray forms[**, steel reinforcement,**] and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

A. ACI Publications: Comply with ACI 301 (ACI 301M) unless otherwise indicated.

2.2 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.

1. Use flexible or uniformly curved forms for curves with a radius of 100 feet (30.5 m) or less.[ **Do not use notched and bent forms.**]

B. 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.

## 2.3 STEEL REINFORCEMENT

A. <Double click to insert sustainable design text for recycled content of steel products.>

B. Plain-Steel Welded-Wire Reinforcement: ASTM A 1064/A 1064M, fabricated from [**as-drawn**] [**galvanized-**]steel wire into flat sheets.

C. Deformed-Steel Welded-Wire Reinforcement: ASTM A 1064/A 1064M, flat sheet.

D. Epoxy-Coated Welded-Wire Reinforcement: ASTM A 884/A 884M, Class A, plain steel.

E. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420); deformed.

F. Galvanized Reinforcing Bars: ASTM A 767/A 767M, Class II zinc coated, hot-dip galvanized after fabrication and bending; with ASTM A 615/A 615M, Grade 60 (Grade 420) deformed bars.

G. Epoxy-Coated Reinforcing Bars: ASTM A 775/A 775M or ASTM A 934/A 934M; with ASTM A 615/A 615M, Grade 60 (Grade 420) deformed bars.

H. Steel Bar Mats: ASTM A 184/A 184M; with ASTM A 615/A 615M, Grade 60 (Grade 420) deformed bars; assembled with clips.

I. Plain-Steel Wire: ASTM A 1064/A 1064M, [**as drawn**] [**galvanized**].

J. Deformed-Steel Wire: ASTM A 1064/A 1064M.

K. Epoxy-Coated-Steel Wire: ASTM A 884/A 884M, Class A; coated, [**plain**] [**deformed**].

L. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 (Grade 420) plain-steel bars[**; zinc coated (galvanized) after fabrication according to ASTM A 767/A 767M, Class I coating**]. Cut bars true to length with ends square and free of burrs.

M. Epoxy-Coated, Joint Dowel Bars: ASTM A 775/A 775M; with ASTM A 615/A 615M, Grade 60 (Grade 420) plain-steel bars.

N. Tie Bars: ASTM A 615/A 615M, Grade 60 (Grade 420); deformed.

O. Hook Bolts: ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6), internally and externally threaded. Design hook-bolt joint assembly to hold coupling against paving form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.

P. 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:

1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.

2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.

Q. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating, compatible with epoxy coating on reinforcement.

R. Zinc Repair Material: ASTM A 780/A 780M.

## 2.4 CONCRETE MATERIALS

A. <Double click to insert sustainable design text for regional materials (concrete).>

B. Cementitious Materials: Use the following cementitious materials, of same type, brand, and source throughout Project:

1. Portland Cement: ASTM C 150/C 150M, [**gray**] [**white**] portland cement [**Type I**] [**Type II**] [**Type I/II**] [**Type III**] [**Type V**].
2. Fly Ash: ASTM C 618, [**Class C**] [**or**] [**Class F**].
3. Slag Cement: ASTM C 989/C 989M, Grade 100 or 120.
4. Blended Hydraulic Cement: ASTM C 595/C 595M, [**Type IS, portland blast-furnace slag**] [**Type IP, portland-pozzolan**] [**Type IL, Portland-limestone**] [**Type IT, ternary blended**] cement.

C. Normal-Weight Aggregates: ASTM C 33/C 33M, [**Class 4S**] [**Class 4M**] [**Class 1N**] <**Insert class**>, 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**].

1. Maximum Coarse-Aggregate Size: [**1-1/2 inches (38 mm)**] [**1 inch (25 mm)**] [**3/4 inch (19 mm)**] nominal.
2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

D. Exposed Aggregate: Selected, hard, and durable; washed; free of materials with deleterious reactivity to cement or that cause staining; from a single source, with gap-graded coarse aggregate as follows:

1. Aggregate Sizes: [**3/4 to 1 inch (19 to 25 mm)**] [**1/2 to 3/4 inch (13 to 19 mm)**] [**3/8 to 5/8 inch (10 to 16 mm)**] <**Insert dimensions**> nominal.
2. Aggregate Source, Shape, and Color: <**Insert requirements**>.

E. Air-Entraining Admixture: ASTM C 260/C 260M.

F. 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.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.

5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

G. Color Pigment: ASTM C 979/C 979M, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable,[ **free of carbon black,**] nonfading, and resistant to lime and other alkalis.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Color: [**As indicated by manufacturer's designation**] [**Match Architect's sample**] [**As selected by Architect from manufacturer's full range**] <**Insert color**>.

H. Water: Potable and complying with ASTM C 94/C 94M.

## 2.5 FIBER REINFORCEMENT

A. Synthetic Fiber: Monofilament 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)**] <**Insert dimensions**> long.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Synthetic Fiber: 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)**] <**Insert dimensions**> long.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

## 2.6 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, [**Class 3, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) dry**] [**or**] [**cotton mats**].

B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

C. Water: Potable.

D. Evaporation Retarder: Waterborne, monomolecular, film forming, manufactured for application to fresh concrete.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

F. White, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 2, Class B, dissipating.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

## 2.7 RELATED MATERIALS

A. Joint Fillers: [**ASTM D 1751, asphalt-saturated cellulosic fiber**] [**or**] [**ASTM D 1752, cork or self-expanding cork**] in preformed strips.

B. Slip-Resistive Aggregate Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive aggregate of fused aluminum-oxide granules or crushed emery aggregate containing not less than 50 percent aluminum oxide and not less than 20 percent ferric oxide; unaffected by freezing, moisture, and cleaning materials.

C. Bonding Agent: ASTM C 1059/C 1059M, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

D. 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:

1. [**Types I and II, nonload bearing**] [**Types IV and V, load bearing**], for bonding hardened or freshly mixed concrete to hardened concrete.

E. Chemical Surface Retarder: Water-soluble, liquid, set retarder with color dye, for horizontal concrete surface application, capable of temporarily delaying final hardening of concrete to a depth of 1/8 to 1/4 inch (3 to 6 mm).

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

F. 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.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Color: [**As indicated by manufacturer's designation**] [**Match Architect's sample**] [**As selected by Architect from manufacturer's full range**] <**Insert color**>.

G. Rock Salt: Sodium chloride crystals, kiln dried, coarse gradation with 100 percent passing 3/8-inch (9.5-mm) sieve and 85 percent retained on a No. 8 (2.36-mm) sieve.

## 2.8 STAMPED DETECTABLE WARNING MATERIALS

A. Detectable Warning Stamp: Semirigid polyurethane mats with formed underside capable of imprinting detectable warning pattern on plastic concrete; perforated with a vent hole at each dome.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Size of Stamp: One piece, [**matching detectable warning area shown on Drawings**] [**24 by 24 inches (610 by 610 mm)**] [**24 by 36 inches (610 by 914 mm)**] [**24 by 48 inches (610 by 1220 mm)**] [**26 by 26 inches (660 by 660 mm)**] [**26 by 36 inches (660 by 914 mm)**] <**Insert dimensions**>.

B. Liquid Release Agent: Manufacturer's standard, clear, evaporating formulation designed to facilitate release of stamp mats.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

## 2.9 CONCRETE MIXTURES

A. 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.

1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.
2. When automatic machine placement is used, determine design mixtures and obtain laboratory test results that comply with or exceed requirements.

B. Cementitious Materials:[ **Use fly ash, pozzolan, slag cement, and silica fume as needed to reduce the total amount of portland cement, which would otherwise be used, by not less than 40 percent.**][ **Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:**]

1. Fly Ash or Pozzolan: 25 percent.
2. Slag Cement: 50 percent.
3. Combined Fly Ash or Pozzolan, and Slag Cement: 50 percent, with fly ash or pozzolan not exceeding 25 percent.

C. 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:

1. Air Content: [**5-1/2**] [**4-1/2**] [**2-1/2**] percent plus or minus 1-1/2 percent for 1-1/2-inch (38-mm) nominal maximum aggregate size.
2. Air Content: [**6**] [**4-1/2**] [**3**] percent plus or minus 1-1/2 percent for 1-inch (25-mm) nominal maximum aggregate size.
3. Air Content: [**6**] [**5**] [**3-1/2**] percent plus or minus 1-1/2 percent for 3/4-inch (19-mm) nominal maximum aggregate size.

D. Limit water-soluble, chloride-ion content in hardened concrete to [**0.15**] [**0.30**] percent by weight of cement.

E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.

1. Use [**water-reducing admixture**] [**high-range, water-reducing admixture**] [**high-range, water-reducing and retarding admixture**] [**plasticizing and retarding admixture**] in concrete as required for placement and workability.
2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

F. 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)**] [**1.5 lb/cu. yd. (0.90 kg/cu. m)**] <**Insert requirement**>.

G. 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.

H. Concrete Mixtures: Normal-weight concrete.

1. Compressive Strength (28 Days): [**4500 psi (31 MPa)**] [**4000 psi (27.6 MPa)**] [**3500 psi (24.1 MPa)**] [**3000 psi (20.7 MPa)**] <**Insert strength**>.
2. Maximum W/C Ratio at Point of Placement: [**0.45**] [**0.50**] <**Insert ratio**>.
3. Slump Limit: [**4 inches (100 mm)**] [**5 inches (125 mm)**] [**8 inches (200 mm)**] <**Insert dimension**>, plus or minus 1 inch (25 mm).
4. <Double click to insert sustainable design text for solar reflectance.>

## 2.10 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M[ **and ASTM C 1116/C 1116M**]. Furnish batch certificates for each batch discharged and used in the Work.

1. 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.

B. 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.

1. 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.
2. 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).
3. 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.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll prepared subbase surface below [**concrete paving**] <**Insert locations**> to identify soft pockets and areas of excess yielding.

1. Completely proof-roll subbase in one direction[ **and repeat in perpendicular direction**]. Limit vehicle speed to 3 mph (5 km/h).
2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons (13.6 tonnes).

3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of [**1/2 inch (13 mm)**] <**Insert dimension**> according to requirements in Section 312000 "Earth Moving."

C. Proceed with installation only after unsatisfactory conditions have been corrected.

## 3.2 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.

## 3.3 EDGE FORMS AND SCREED CONSTRUCTION

A. 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.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

## 3.4 STEEL REINFORCEMENT INSTALLATION

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.

D. 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.

E. Zinc-Coated Reinforcement: Use galvanized-steel wire ties to fasten zinc-coated reinforcement. Repair cut and damaged zinc coatings with zinc repair material.

F. Epoxy-Coated Reinforcement: Use epoxy-coated steel wire ties to fasten epoxy-coated reinforcement. Repair cut and damaged epoxy coatings with epoxy repair coating according to ASTM D 3963/D 3963M.

G. 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 of adjacent mats.

## 3.5 JOINTS

A. 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.

1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.

B. 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.

1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
2. Provide tie bars at sides of paving strips where indicated.
3. Butt Joints: Use [**bonding agent**] [**epoxy-bonding adhesive**] at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
4. 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.
5. Doweled 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.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.

1. Locate expansion joints at intervals of [**50 feet (15.25 m)**] <**Insert dimension**> unless otherwise indicated.
2. Extend joint fillers full width and depth of joint.
3. 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.
4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
6. 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.

D. 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 concrete paving**]:

1. 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)**] [**3/8-inch (10-mm)**] radius. Repeat grooving of contraction joints after applying surface finishes.[ **Eliminate grooving-tool marks on concrete surfaces.**]

a. Tolerance: Ensure that grooved joints are within [**3 inches (75 mm)**] <**Insert dimension**> either way from centers of dowels.

2. 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.

   a. Tolerance: Ensure that sawed joints are within [**3 inches (75 mm)**] <**Insert dimension**> either way from centers of dowels.

3. 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.

E. 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)**] [**3/8-inch (10-mm)**] radius. Repeat tooling of edges after applying surface finishes.[ **Eliminate edging-tool marks on concrete surfaces.**]

## 3.6 CONCRETE PLACEMENT

A. Before placing concrete, inspect and complete formwork installation[**, steel reinforcement,**] and items to be embedded or cast-in.

B. Remove snow, ice, or frost from subbase surface[ **and steel reinforcement**] before placing concrete. Do not place concrete on frozen surfaces.

C. 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.

D. Comply with ACI 301 (ACI 301M) requirements for measuring, mixing, transporting, and placing concrete.

E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.

F. 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.

G. Consolidate concrete according to ACI 301 (ACI 301M) by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.

1. 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.

H. Screed paving surface with a straightedge and strike off.

I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleedwater appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

J. Curbs and Gutters: Use design mixture for automatic machine placement. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing.

K. Slip-Form Paving: Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.

1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.

## 3.7 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleedwater 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.

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.

## 3.8 SPECIAL FINISHES

A. Monolithic Exposed-Aggregate Finish: Expose coarse aggregate in paving surface as follows:

1. Immediately after float finishing, spray-apply chemical surface retarder to paving according to manufacturer's written instructions.
2. Cover paving surface with plastic sheeting, sealing laps with tape, and remove when ready to continue finishing operations.
3. Without dislodging aggregate, remove mortar concealing the aggregate by lightly brushing surface with a stiff, nylon-bristle broom. Do not expose more than one-third of the average diameter of the aggregate and not more than one-half of the diameter of the smallest aggregate.
4. Fine-spray surface with water and brush. Repeat cycle of water flushing and brushing until cement film is removed from aggregate surfaces to depth required.

B. Seeded Exposed-Aggregate Finish: Immediately after initial floating, spread a single layer of aggregate uniformly on paving surface. Tamp aggregate into plastic concrete and float finish to entirely embed aggregate with mortar cover of 1/16 inch (1.6 mm).

1. Spray-apply chemical surface retarder to paving according to manufacturer's written instructions.

2. Cover paving surface with plastic sheeting, sealing laps with tape, and remove sheeting when ready to continue finishing operations.
3. Without dislodging aggregate, remove mortar concealing the aggregate by lightly brushing surface with a stiff, nylon-bristle broom. Do not expose more than one-third of the average diameter of the aggregate and not more than one-half of the diameter of the smallest aggregate.
4. Fine-spray surface with water and brush. Repeat cycle of water flushing and brushing until cement film is removed from aggregate surfaces to depth required.

C. Slip-Resistive Aggregate Finish: Before final floating, spread slip-resistive aggregate finish on paving surface according to manufacturer's written instructions and as follows:

1. Uniformly spread [**25 lb/100 sq. ft. (12 kg/10 sq. m)**] [**40 lb/100 sq. ft. (19.5 kg/10 sq. m)**] [**60 lb/100 sq. ft. (29 kg/10 sq. m)**] <**Insert rate of application**> of dampened, slip-resistive aggregate over paving surface in two applications. Tamp aggregate flush with surface using a steel trowel, but do not force below surface.
2. Uniformly distribute approximately two-thirds of slip-resistive aggregate over paving surface with mechanical spreader, allow to absorb moisture, and embed by power floating. Follow power floating with a second slip-resistive aggregate application, uniformly distributing remainder of material at right angles to first application to ensure uniform coverage, and embed by power floating.
3. Cure concrete with curing compound recommended by slip-resistive aggregate manufacturer. Apply curing compound immediately after final finishing.
4. After curing, lightly work surface with a steel-wire brush or abrasive stone and water to expose nonslip aggregate.

D. Rock-Salt Finish: After initial [**floating**] [**troweling**] [**brooming**], uniformly spread rock salt over paving surface at the rate of 5 lb/100 sq. ft. (0.2 kg/10 sq. m).

1. Embed rock salt into plastic concrete with [**roller**] [**or**] [**magnesium float**] <**Insert tool**>.
2. Cover paving surface with 1-mil- (0.025-mm-) thick polyethylene sheet and remove sheet when concrete has hardened and seven-day curing period has elapsed.
3. After seven-day curing period, saturate concrete with water and broom-sweep surface to dissolve remaining rock salt, thereby leaving pits and holes.

E. Pigmented Mineral Dry-Shake Hardener Finish: After initial floating, apply dry-shake materials to paving surface according to manufacturer's written instructions and as follows:

1. Uniformly spread dry-shake hardener at a rate of [**100 lb/100 sq. ft. (49 kg/10 sq. m)**] <**Insert rate of application**> unless greater amount is recommended by manufacturer to match paving color required.
2. 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.
3. After final power floating, apply a hand-troweled finish followed by a broom finish.
4. Cure concrete with curing compound recommended by dry-shake hardener manufacturer. Apply curing compound immediately after final finishing.

## 3.9 DETECTABLE WARNING INSTALLATION

A. Blockouts: Form blockouts in concrete for installation of detectable paving units specified in Section 321726 "Tactile Warning Surfacing."

1. Tolerance for Opening Size: [**Plus 1/4 inch (6 mm), no minus**] <**Insert requirement**>.

B. Cast-in-Place Detectable Warning Tiles: Form blockouts in concrete for installation of tiles specified in Section 321726 "Tactile Warning Surfacing." Screed surface of concrete where tiles are to be installed to elevation, so that edges of installed tiles will be flush with surrounding concrete paving. Embed tiles in fresh concrete to comply with Section 321726 "Tactile Warning Surfacing" immediately after screeding concrete surface.

C. Stamped Detectable Warnings: Install stamped detectable warnings as part of a continuous concrete paving placement and according to stamp-mat manufacturer's written instructions.

1. Before using stamp mats, verify that the vent holes are unobstructed.
2. Apply liquid release agent to the concrete surface and the stamp mat.
3. Stamping: [**While initially finished concrete is plastic**] [**After application and final floating of pigmented mineral dry-shake hardener**], accurately align and place stamp mats in sequence. Uniformly load, gently vibrate, and press mats into concrete to produce imprint pattern on concrete surface. Load and tamp mats directly perpendicular to the stamp-mat surface to prevent distortion in shape of domes. Press and tamp until mortar begins to come through all of the vent holes. Gently remove stamp mats.
4. Trimming: After [**24**] <**Insert number**> hours, cut off the tips of mortar formed by the vent holes.
5. 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.

## 3.10 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. 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.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by [**moisture curing**] [**moisture-retaining-cover curing**] [**curing compound**] [**or**] [**a combination of these**] as follows:

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

    a. Water.
    b. Continuous water-fog spray.
    c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch (300-mm) lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive. Immediately repair any holes or tears occurring during installation or curing period, using cover material and waterproof tape.
3. Curing 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. Maintain continuity of coating, and repair damage during curing period.

## 3.11 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 (ACI 117M) and as follows:

1. Elevation: 3/4 inch (19 mm).
2. Thickness: Plus 3/8 inch (10 mm), minus 1/4 inch (6 mm).
3. Surface: Gap below 10-feet- (3-m-) long; unleveled straightedge not to exceed 1/2 inch (13 mm).
4. Alignment of Tie-Bar End Relative to Line Perpendicular to Paving Edge: 1/2 inch per 12 inches (13 mm per 300 mm) of tie bar.
5. Lateral Alignment and Spacing of Dowels: 1 inch (25 mm).
6. Vertical Alignment of Dowels: 1/4 inch (6 mm).
7. 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.
8. Joint Spacing: 3 inches (75 mm).
9. Contraction Joint Depth: Plus 1/4 inch (6 mm), no minus.
10. Joint Width: Plus 1/8 inch (3 mm), no minus.

## 3.12 FIELD QUALITY CONTROL

A. Testing Agency: [**Owner will engage**] [**Engage**] a qualified testing agency to perform tests and inspections.

B. Testing Services: Testing and inspecting of composite samples of fresh concrete obtained according to ASTM C 172/C 172M shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least one composite sample for each [**100 cu. yd. (76 cu. m)**] [**5000 sq. ft. (465 sq. m)**] or fraction thereof of each concrete mixture placed each day.

a. 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.

2. 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.
3. Air Content: ASTM C 231/C 231M, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
4. 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.
5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
6. Compressive-Strength Tests: ASTM C 39/C 39M; test one specimen at seven days and two specimens at 28 days.

a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.

C. 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).

D. Test results shall be reported in writing to Architect, 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.

E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.

F. 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 Architect.

G. Concrete paving will be considered defective if it does not pass tests and inspections.

H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

I. Prepare test and inspection reports.

## 3.13 REPAIR AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.

B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with portland cement concrete bonded to paving with epoxy adhesive.

C. Protect 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.

D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 32 13 13

# SECTION 32 13 73 - CONCRETE PAVING JOINT SEALANTS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. Section Includes:

1. Cold-applied joint sealants.
2. Hot-applied joint sealants.
3. Cold-applied, fuel-resistant joint sealants.
4. Hot-applied, fuel-resistant joint sealants.
5. Joint-sealant backer materials.
6. Primers.

B. Related Requirements:

1. Section 079200 "Joint Sealants" for sealing nontraffic and traffic joints in locations not specified in this Section.

### 1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at [**Project site**] <**Insert location**>.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples for Verification: For each kind and color of joint sealant required, provide Samples with joint sealants in 1/2-inch- (13-mm-) wide joints formed between two 6-inch- (150-mm-) long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.

C. Paving-Joint-Sealant Schedule: Include the following information:

1. Joint-sealant application, joint location, and designation.
2. Joint-sealant manufacturer and product name.
3. Joint-sealant formulation.
4. Joint-sealant color.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For [**Installer**] [**testing agency**].

B. Product Certificates: For each type of joint sealant and accessory.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Product Testing: Test joint sealants using a qualified testing agency.

1.7 FIELD CONDITIONS

A. Do not proceed with installation of joint sealants under the following conditions:

1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer[ **or are below 40 deg F (5 deg C)**].
2. When joint substrates are wet.
3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

2.2 COLD-APPLIED JOINT SEALANTS

A. Single-Component, Nonsag, Silicone Joint Sealant: ASTM D 5893/D 5893M, Type NS.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Single-Component, Self-Leveling, Silicone Joint Sealant: ASTM D 5893/D 5893M, Type SL.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Multicomponent, Nonsag, Urethane, Elastomeric Joint Sealant: ASTM C 920, Type M, Grade NS, Class 25, for Use T.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

D. Single Component, Pourable, Urethane, Elastomeric Joint Sealant: ASTM C 920, Type S, Grade P, Class 25, for Use T.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

E. Multicomponent, Pourable, Urethane, Elastomeric Joint Sealant: ASTM C 920, Type M, Grade P, Class 25, for Use T.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

## 2.3 HOT-APPLIED JOINT SEALANTS

A. Hot-Applied, Single-Component Joint Sealant: ASTM D 6690, Type I.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Hot-Applied, Single-Component Joint Sealant: ASTM D 6690, Type I or Type II.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Hot-Applied, Single-Component Joint Sealant: ASTM D 6690, Type I, II, or III.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

D. Hot-Applied, Single-Component Joint Sealant: ASTM D 6690, Type IV.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

## 2.4 COLD-APPLIED, FUEL-RESISTANT JOINT SEALANTS

A. Fuel-Resistant, Single-Component, Pourable, Modified-Urethane, Elastomeric Joint Sealant: ASTM C 920, Type S, Grade P, Class 25, for Use T.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Fuel-Resistant, Multicomponent, Pourable, Modified-Urethane, Elastomeric Joint Sealant: ASTM C 920, Type M, Grade P, Class 12-1/2 or 25, for Use T.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

## 2.5 HOT-APPLIED, FUEL-RESISTANT JOINT SEALANTS

A. Hot-Applied, Fuel-Resistant, Single-Component Joint Sealants: ASTM D 7116, Type I or Type II.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Hot-Applied, Fuel-Resistant, Single-Component Joint Sealants: ASTM D 7116, Type III.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

## 2.6 JOINT-SEALANT BACKER MATERIALS

A. Joint-Sealant Backer Materials: Nonstaining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by joint-sealant manufacturer, based on field experience and laboratory testing.

B. Round Backer Rods for Cold- and Hot-Applied Joint Sealants: ASTM D 5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

C. Round Backer Rods for Cold-Applied Joint Sealants: ASTM D 5249, Type 3, of diameter and density required to control joint-sealant depth and prevent bottom-side adhesion of sealant.

D. Backer Strips for Cold- and Hot-Applied Joint Sealants: ASTM D 5249; Type 2; of thickness and width required to control joint-sealant depth, prevent bottom-side adhesion of sealant, and fill remainder of joint opening under sealant.

## 2.7 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine joints to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

## 3.2 PREPARATION

A. Surface Cleaning of Joints: Before installing joint sealants, clean out joints immediately to comply with joint-sealant manufacturer's written instructions.

1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.

B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior

experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

## 3.3 INSTALLATION OF JOINT SEALANTS

A. Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.

B. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions.

C. Install joint-sealant backings to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.

1. Do not leave gaps between ends of joint-sealant backings.
2. Do not stretch, twist, puncture, or tear joint-sealant backings.
3. Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.

D. Install joint sealants immediately following backing installation, using proven techniques that comply with the following:

1. Place joint sealants so they fully contact joint substrates.
2. Completely fill recesses in each joint configuration.
3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

E. Tooling of Nonsag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants according to the following requirements to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:

1. Remove excess joint sealant from surfaces adjacent to joints.
2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.

F. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

## 3.4 CLEANING AND PROTECTION

A. Clean off excess joint sealant as the Work progresses, by methods and with cleaning materials approved in writing by joint-sealant manufacturers.

B. Protect joint sealants, during and after curing period, from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such

protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations in repaired areas are indistinguishable from the original work.

## 3.5 PAVING-JOINT-SEALANT SCHEDULE

A. Joint-Sealant Application: Joints within concrete paving[ <**PJS-#**>].

1. Joint Location:

   a. Expansion and isolation joints in concrete paving.
   b. Contraction joints in concrete paving.
   c. Other joints as indicated.

2. Joint Sealant: [**Single-component, nonsag, silicone joint sealant**] [**Single-component, self-leveling, silicone joint sealant**] [**Multicomponent, nonsag, urethane, elastomeric joint sealant**] [**Single component, pourable, urethane, elastomeric joint sealant**] [**Multicomponent, pourable, urethane, elastomeric joint sealant**] [**Hot-applied, single-component joint sealant**] <**Insert joint sealant**>.
3. Joint-Sealant Color: [**Manufacturer's standard**] <**Insert color**>.

B. Joint-Sealant Application: Joints within concrete paving and between concrete and asphalt paving[ <**PJS-#**>].

1. Joint Location:

   a. Joints between concrete and asphalt paving.
   b. Joints between concrete curbs and asphalt paving.
   c. Other joints as indicated.

2. Joint Sealant: [**Hot-applied, single-component joint sealant**] <**Insert joint sealant**>.
3. Joint-Sealant Color: [**Manufacturer's standard**] <**Insert color**>.

C. Joint-Sealant Application: Fuel-resistant joints within concrete paving[ <**PJS-#**>].

1. Joint Location:

   a. Expansion and isolation joints in concrete paving.
   b. Contraction joints in concrete paving.
   c. Other joints as indicated.

2. Joint Sealant: [**Fuel-resistant, single-component, pourable, modified-urethane, elastomeric joint sealant**] [**Fuel-resistant, multicomponent, pourable, modified-urethane, elastomeric joint sealant**] [**Hot-applied, fuel-resistant, single-component joint sealant**] <**Insert joint sealant**>.
3. Joint-Sealant Color: [**Manufacturer's standard**] <**Insert color**>.

END OF SECTION 32 13 73

# SECTION 32 17 13 - PARKING BUMPERS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. Section includes wheel stops.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. <Double click to insert sustainable design text for recycled content.>

C. Samples for Initial Selection: For each type of exposed finish requiring color selection.

D. Samples for Verification: For wheel stops, [**6 inches (150 mm) long**] <**Insert dimension**>, showing color and cross section; with fasteners.

## PART 2 - PRODUCTS

### 2.1 PARKING BUMPERS

A. Concrete Wheel Stops: Precast, steel-reinforced, air-entrained concrete, [**4000-psi (27.6-MPa)**] <**Insert value**> minimum compressive strength, [**4-1/2 inches (115 mm) high by 9 inches (225 mm) wide by 72 inches (1800 mm) long**] <**Insert dimensions**>. Provide chamfered corners, transverse drainage slots on underside, and a minimum of [**two**] [**three**] factory-formed or -drilled vertical holes through wheel stop for anchoring to substrate.

1. Surface Appearance: Free of pockets, sand streaks, honeycombs, and other obvious defects. Corners shall be uniform, straight, and sharp.
2. Mounting Hardware: Galvanized-steel [**spike or dowel, 1/2-inch (13-mm) diameter, 10-inch (254-mm) minimum length**] [**lag screw, shield, and washers; 1/2-inch (13-mm) diameter, 8-inch (203-mm) minimum length**] [**hardware as standard with wheel-stop manufacturer**].

B. Resilient Wheel Stops: Solid, integrally colored, 96 percent postconsumer or commingled postconsumer and preconsumer recycled [**rubber**] [**or**] [**plastic**]; UV stabilized; [**4 inches (100**

**mm) high by 6 inches (150 mm) wide by 72 inches (1800 mm) long**] <**Insert dimensions**>. Provide chamfered corners and a minimum of [**two**] [**three**] [**four**] factory-formed or -drilled vertical holes through wheel stop for anchoring to substrate.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Color: [**Black**] [**Yellow**] [**Gray**] [**Green**] [**Blue**] <**Insert color**>.
3. Embedded Markings: Molded-in, [**blue**] [**white**] [**yellow**] reflective markings, permanently inset in exposed surface.
4. Mounting Hardware: Galvanized-steel [**spike or dowel, 1/2-inch (13-mm) diameter, 10-inch (254-mm) minimum length**] [**lag screw, shield, and washers; 1/2-inch (13-mm) diameter, 8-inch (203-mm) minimum length**] [**hardware as standard with wheel-stop manufacturer**].
5. Adhesive: As recommended by wheel-stop manufacturer for adhesion to pavement.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Verify that pavement is in suitable condition to begin installation according to manufacturer's written instructions.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

A. General: Install wheel stops according to manufacturer's written instructions unless otherwise indicated.

B. Install wheel stops in bed of adhesive before anchoring.

C. Securely anchor wheel stops to pavement with hardware in each preformed vertical hole in wheel stop as recommended in writing by manufacturer. Recess head of hardware beneath top of wheel stop.

END OF SECTION 32 17 13

# SECTION 32 17 23 - PAVEMENT MARKINGS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. Section includes painted markings applied to asphalt and concrete pavement.

B. Related Requirements:

1. Section 099113 "Exterior Painting" for painting exterior concrete surfaces other than pavement.
2. Section 099123 "Interior Painting" for painting interior concrete surfaces other than pavement.

### 1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at [**Project site**] <**Insert location**>.

1. Review methods and procedures related to marking pavement including, but not limited to, the following:

a. Pavement aging period before application of pavement markings.
b. Review requirements for protecting pavement markings, including restriction of traffic during installation period.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include technical data and tested physical and performance properties.

B. Shop Drawings: For pavement markings.

1. Indicate pavement markings, colors, lane separations, defined parking spaces, and dimensions to adjacent work.
2. Indicate, with international symbol of accessibility, spaces allocated for people with disabilities.

C. Samples: For each exposed product and for each color and texture specified; on rigid backing, 8 inches (200 mm) square.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of <**Insert applicable standards**> of <**Insert name of state or local DOT**> for pavement-marking work.

1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

1.6 FIELD CONDITIONS

A. Environmental Limitations: 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 alkyd materials**] [**55 deg F (12.8 deg C) for water-based materials**], and not exceeding 95 deg F (35 deg C).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2.2 PAVEMENT-MARKING PAINT

A. Pavement-Marking Paint: Alkyd-resin type, lead and chromate free, ready mixed, complying with AASHTO M 248, [**Type N**] [**Type F**] [**Type S**]; colors complying with FS TT-P-1952.

1. Color: [**White**] [**Yellow**] [**Blue**] [**As indicated**] <**Insert color**>.

B. Pavement-Marking Paint: MPI #32, alkyd traffic-marking paint.

1. Color: [**White**] [**Yellow**] [**Blue**] [**As indicated**] <**Insert color**>.

C. Pavement-Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, Type II, with drying time of less than [**three**] [**45**] minutes.

1. Color: [**White**] [**Yellow**] [**Blue**] [**As indicated**] <**Insert color**>.

D. Pavement-Marking Paint: MPI #97, latex traffic-marking paint.

1. Color: [**White**] [**Yellow**] [**Blue**] [**As indicated**] <**Insert color**>.

E. Glass Beads: AASHTO M 247, Type 1[ **made of 100 percent recycled glass**].

1. Roundness: Minimum [**75**] [**80**] percent true spheres by weight.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that pavement is dry and in suitable condition to begin pavement marking according to manufacturer's written instructions.

B. Proceed with pavement marking only after unsatisfactory conditions have been corrected.

3.2 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.

B. Allow paving to age for a minimum of [**30**] [**90**] <**Insert number**> days before starting pavement marking.

C. Sweep and clean surface to eliminate loose material and dust.

D. 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)**] <**Insert dimension**>.

1. Apply graphic symbols and lettering with paint-resistant, die-cut stencils, firmly secured to pavement. Mask an extended area beyond edges of each stencil to prevent paint application beyond the stencil. Apply paint so that it cannot run beneath the stencil.
2. Broadcast glass beads uniformly into wet markings at a rate of 6 lb/gal. (0.72 kg/L).

3.3 PROTECTING AND CLEANING

A. Protect pavement markings from damage and wear during remainder of construction period.

B. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 32 17 23

# SECTION 32 17 26 - TACTILE WARNING SURFACING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. Section Includes:

1. Cast-in-place detectable warning tiles.
2. Detectable warning unit pavers.

B. Related Requirements:

1. Section 321313 "Concrete Paving" for concrete walkways serving as substrates for tactile warning surfacing.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. <Double click to insert sustainable design text for recycled content.>
2. <Double click to insert sustainable design text for regional materials.>

C. Samples for Initial Selection: For each type of exposed finish requiring color selection.

D. Samples for Verification: For each type of tactile warning surface, in manufacturer's standard sizes unless otherwise indicated, showing edge condition, truncated-dome pattern, texture, color, and cross section; with fasteners and anchors.

### 1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For tactile warning surfacing, to include in maintenance manuals.

### 1.5 QUALITY ASSURANCE

A. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.

1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

## 1.6 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at [**Project site**] <**Insert location**>.

## 1.7 PROJECT CONDITIONS

A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.

B. Weather Limitations for Adhesive Application:

1. Apply 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 substrate is wet or contains excess moisture.

C. Weather Limitations for Mortar and Grout:

1. Cold-Weather Requirements: Comply with cold-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602.
2. 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.

a. 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 unit pavers within 1 minute of spreading setting-bed mortar.

## 1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of tactile warning surfaces that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Deterioration of finishes beyond normal weathering and wear.
b. Separation or delamination of materials and components.

2. Warranty Period: [**Five**] <**Insert number**> years from date of Substantial Completion.

PART 2 - PRODUCTS

## 2.1 TACTILE WARNING SURFACING, GENERAL

A. Accessibility Requirements: Comply with applicable provisions in [**the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines for Buildings and Facilities**] [**and**] [**ICC A117.1**] for tactile warning surfaces.

1. For tactile warning surfaces composed of multiple units, provide units that when installed provide consistent side-to-side and end-to-end dome spacing that complies with requirements.

B. <Double click to insert sustainable design text for recycled content.>

C. <Double click to insert sustainable design text for regional materials.>

D. Source Limitations: Obtain each type of tactile warning surfacing[**, joint material**] [**, setting material**] [**, anchor**] [**, and**] [**fastener**] from single source with resources to provide materials and products of consistent quality in appearance and physical properties.

## 2.2 DETECTABLE WARNING TILES

A. Cast-in-Place Detectable Warning Tiles: Accessible truncated-dome detectable warning tiles[ **with replaceable surface**] configured for setting flush in new concrete walkway surfaces, with slip-resistant surface treatment on domes and field of tile.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Material: [**Cast-fiber-reinforced polymer concrete tile**] [**Molded glass- and carbon-fiber-reinforced polyester**].
3. Color: [**Safety yellow**] [**Red brick**] [**Black**] [**Gray**] [**As selected by Architect from manufacturer's full line**].
4. Shapes and Sizes:

    a. Rectangular panel, [**12 by 12 inches (305 by 305 mm)**] [**24 by 24 inches (610 by 610 mm)**] [**24 by 36 inches (610 by 914 mm)**] [**24 by 48 inches (610 by 1219 mm)**] [**24 by 60 inches (610 by 1524 mm)**] [**36 by 48 inches (914 by 1219 mm)**] [**36 by 60 inches (914 by 1524 mm)**] <**Insert dimensions**>.
    b. Radius panel, nominal 24 inches (610 mm) deep by [**6-foot (1829-mm)**] [**8-foot (2438-mm)**] [**10-foot (3048-mm)**] [**12-foot (3658-mm)**] [**15-foot (4572-mm)**] <**Insert dimension**> outside radius.

5. Dome Spacing and Configuration: [**1.67-inch (42.4-mm) spacing**] [**2.35-inch (59.7-mm) spacing**] [**Manufacturer's standard compliant spacing**] <**Insert spacing**>, in [**square**] [**diamond**] [**manufacturer's standard**] pattern.
6. Mounting:

    a. Permanently embedded detectable warning tile wet-set into freshly poured concrete.

b. Detectable warning tile set into formed recess in concrete and adhered with [**mortar**] [**adhesive**].
c. Replaceable detectable warning tile wet-set into freshly poured concrete and surface-fastened to permanently embedded anchors.

B. Surface-Applied Detectable Warning Tiles: Accessible truncated-dome detectable warning concrete tiles configured for surface application on existing concrete walkway surfaces, with slip-resistant surface treatment on domes, field of tile, and beveled outside edges.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Material: [**Cast-fiber-reinforced polymer concrete tile**] [**Molded glass- and carbon-fiber-reinforced polyester**].
3. Color: [**Safety yellow**] [**Red brick**] [**Black**] [**Gray**] [**As selected by Architect from manufacturer's full line**].
4. Shapes and Sizes:

a. Rectangular panel, [**12 by 12 inches (305 by 305 mm)**] [**24 by 24 inches (610 by 610 mm)**] [**24 by 36 inches (610 by 914 mm)**] [**24 by 48 inches (610 by 1219 mm)**] [**24 by 60 inches (610 by 1524 mm)**] [**36 by 48 inches (914 by 1219 mm)**] [**36 by 60 inches (914 by 1524 mm)**] <**Insert dimensions**>.
b. Radius panel, nominal 24 inches (610 mm) deep by [**6-foot (1829-mm)**] [**8-foot (2438-mm)**] [**10-foot (3048-mm)**] [**12-foot (3658-mm)**] [**15-foot (4572-mm)**] <**Insert dimension**> outside radius.

5. Dome Spacing and Configuration: [**1.67-inch (42.4-mm) spacing**] [**2.35-inch (59.7-mm) spacing**] [**Manufacturer's standard compliant spacing**] <**Insert spacing**>, in [**square**] [**diamond**] [**manufacturer's standard**] pattern.
6. Mounting: Adhered[ **and fastened**] to existing concrete walkway.

C. Cast-in-Place Detectable Warning Metal Tiles: Accessible truncated-dome detectable warning metal tiles[ **with replaceable surface**] configured for setting flush in new concrete walkway surfaces, with slip-resistant surface treatment on domes and field of tile.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Material:

a. Stainless-Steel Plate and Sheet: ASTM A 240/A 240M or ASTM A 666, [**Type 304**] [**Type 316L**].

1) Finish and Color:

a) Manufacturer's standard powder coat, [**safety yellow**] [**red brick**] [**black**] [**gray**] [**color as selected by Architect from manufacturer's full line**].
b) Mill finish.

b. Cast Iron: Gray iron, ASTM A 48/A 48M, CL 35.

3. Shapes and Sizes:

a. Rectangular panel, [**12 by 12 inches (305 by 305 mm)**] [**18 by 24 inches (457 by 610 mm)**] [**24 by 24 inches (610 by 610 mm)**] [**24 by 36 inches (610 by 914 mm)**] [**24 by 48 inches (610 by 1219 mm)**] [**24 by 60 inches (610 by 1524 mm)**] [**36 by 48 inches (914 by 1219 mm)**] [**36 by 60 inches (914 by 1524 mm)**] <**Insert dimensions**>.
b. Radius panel, nominal 24 inches (610 mm) deep by [**6-foot (1829-mm)outside radius**] [**8-foot (2438-mm)outside radius**] [**10-foot (3048-mm)outside radius**] [**12-foot (3658-mm)outside radius**] [**15-foot (4572-mm) outside radius**] [**17.5-foot (5334-mm)outside radius**] [**outside radius indicated on Drawings**] <**Insert dimension**>.

4. Dome Spacing and Configuration: [**1.67-inch (42.4-mm) spacing**] [**2.35-inch (59.7-mm) spacing**] [**Manufacturer's standard compliant spacing**] <**Insert spacing**>, in [**square**] [**diamond**] [**manufacturer's standard**] pattern.
5. Mounting:

a. Permanently embedded detectable warning tile wet-set into freshly poured concrete.
b. Permanently embedded detectable warning tile set into formed recess in concrete and adhered with [**mortar**] [**adhesive**].
c. Replaceable embedded detectable warning tile fastened to permanently installed anchors.

D. Surface-Applied Detectable Warning Metal Tiles: Accessible truncated-dome detectable warning metal tiles or plates configured for fastening to surface of existing concrete walkway surfaces, with slip-resistant surface treatment on domes, field of tile, and beveled outside edges.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Material: Stainless-Steel Plate and Sheet: ASTM A 240/A 240M or ASTM A 666, [**Type 304**] [**Type 316L**].
3. Finish and Color:

a. Manufacturer's standard powder coat, [**safety yellow**] [**red brick**] [**black**] [**gray**] [**color as selected by Architect from manufacturer's full line**].
b. Mill finish.

4. Shapes and Sizes:

a. Rectangular panel, [**24 by 24 inches (610 by 610 mm)**] [**24 by 36 inches (610 by 914 mm)**] [**24 by 48 inches (610 by 1219 mm)**] [**24 by 60 inches (610 by 1524 mm)**] <**Insert dimensions**>.

5. Dome Spacing and Configuration: [**1.67-inch (42.4-mm) spacing**] [**2.35-inch (59.7-mm) spacing**] [**Manufacturer's standard compliant spacing**] <**Insert spacing**>, in [**square**] [**diamond**] [**manufacturer's standard**] pattern.
6. Mounting:

a. Replaceable surface-applied detectable warning tile fastened with permanently installed anchors to existing concrete walkway.
b. Permanently fixed detectable warning tile adhered[ **and fastened**] to existing concrete walkway.

## 2.3 DETECTABLE WARNING MATS

A. Surface-Applied Detectable Warning Mats: Accessible truncated-dome detectable warning resilient mats, UV resistant, manufactured for adhering to existing concrete walkway surfaces, with slip-resistant surface treatment on domes, field of mat, and beveled outside edges.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Material: Modified rubber compound, UV resistant.
3. Color: [**As indicated by manufacturer's designations**] [**Match Architect's sample**] [**As selected by Architect from manufacturer's full range**] <**Insert color**>.
4. Shapes and Sizes:

    a. Rectangular panel, [**24 by 36 inches (610 by 914 mm)**] [**24 by 48 inches (610 by 1219 mm)**] [**24 by 60 inches (610 by 1524 mm)**] <**Insert dimensions**>.

5. Dome Spacing and Configuration: [**1.67-inch (42.4-mm) spacing**] [**2.35-inch (59.7-mm) spacing**] [**Manufacturer's standard compliant spacing**] <**Insert spacing**>, in [**square**] [**diamond**] [**manufacturer's standard**] pattern.
6. Mounting: Adhered to pavement surface with adhesive[ **and fastened with fasteners**].

## 2.4 DETECTABLE WARNING UNIT PAVERS

A. Detectable Warning Concrete Unit Pavers: Solid paving units, made from normal-weight concrete with a compressive strength of not less than 5000 psi (34 MPa) <**Insert value**>, water absorption of 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, with accessible detectable warning truncated domes on exposed surface of units.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Shapes and Sizes:

    a. Thickness: [**2 inches (51 mm)**] [**2-1/2 inches (63 mm)**] <**Insert dimension**> at field of tile.
    b. Face Size: Nominal [**12 by 12 inches (305 by 305 mm)**] [**24 by 24 inches (610 by 610 mm)**] <**Insert dimensions**>.

3. Dome Spacing and Configuration: [**1.67-inch (42.4-mm) spacing**] [**2.35-inch (59.7-mm) spacing**] [**Manufacturer's standard compliant spacing**] <**Insert spacing**>, in [**square**] [**diamond**] [**manufacturer's standard**] pattern.
4. Color: [**As indicated by manufacturer's designations**] [**Match Architect's sample**] [**As selected by Architect from manufacturer's full range**] <**Insert color**>.

B. Setting Bed: Comply with requirements in Section 321400 "Unit Paving."

C. Aggregate Setting Bed:

1. Graded Aggregate for Base: Sound, crushed stone or gravel complying with ASTM D 448 for Size No. 8.
2. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33/C 33M for fine aggregate.

3. 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.

D. Mortar Setting Bed:

1. Portland Cement: ASTM C 150/C 150M, Type I or Type II.
2. Sand: ASTM C 33/C 33M.
3. Latex Additive: Manufacturer's standard water emulsion, 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.
4. Thinset Mortar: Latex-modified portland cement mortar complying with ANSI A118.4.
5. Water: Potable.

## 2.5 ACCESSORIES

A. Fasteners and Anchors: Manufacturer's standard as required for secure anchorage of tactile warning surfaces, noncorrosive and compatible with each material joined, and complying with the following:

1. Furnish [**Type 304**] [**Type 316**] stainless-steel fasteners for exterior use.
2. Fastener Heads: For nonstructural connections, use flathead or oval countersunk screws and bolts with tamper-resistant heads, colored to match tile.

B. Adhesive: As recommended by manufacturer for adhering tactile warning surfacing unit to pavement.

C. Sealant: As recommended by manufacturer for sealing perimeter of tactile warning surfacing unit.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Verify that pavement is in suitable condition to begin installation according to manufacturer's written instructions. Verify that installation of tactile warning surfacing will comply with accessibility requirements upon completion.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

## 3.2 INSTALLATION OF TACTILE WARNING SURFACING

A. General: Prepare substrate and install tactile warning surfacing according to manufacturer's written instructions unless otherwise indicated.

B. Place tactile warning surfacing units in dimensions and orientation indicated. Comply with location requirements of AASHTO MP 12.

## 3.3 INSTALLATION OF DETECTABLE WARNING TILES

A. Cast-in-Place Detectable Warning Tiles:

1. Concrete Paving Installation: Comply with installation requirements in Section 321313 "Concrete Paving." Mix, place, and finish concrete to conditions complying with detectable warning tile manufacturer's written requirements for satisfactory embedment of tile.
2. Set each detectable warning tile accurately and firmly in place and completely seat tile back and embedments in wet concrete by tamping or vibrating. If necessary, temporarily apply weight to tiles to ensure full contact with concrete.
3. Set surface of tile flush with surrounding concrete and adjacent tiles, with variations between tiles and between concrete and tiles not exceeding plus or minus 1/8 inch (3 mm) from flush.
4. Protect exposed surfaces of installed tiles from contact with wet concrete. Complete finishing of concrete paving surrounding tiles. Remove concrete from tile surfaces.
5. Clean tiles using methods recommended in writing by manufacturer.

B. Removable Cast-in-Place Detectable Warning Tiles:

1. Concrete Paving Installation: Comply with installation requirements in Section 321313 "Concrete Paving." Mix, place, and finish concrete to conditions complying with detectable warning tile manufacturer's written requirements for satisfactory embedment of removable tile.
2. Set each detectable warning tile accurately and firmly in place with embedding anchors and fasteners attached, and firmly seat tile back in wet concrete by tamping or vibrating. If necessary, temporarily apply weight to tiles to ensure full contact with concrete.
3. Set surface of tile flush with surrounding concrete and adjacent tiles, with variations between tiles and between concrete and tiles not exceeding plus or minus 1/8 inch (3 mm) from flush.
4. Protect exposed surfaces of installed tiles from contact with wet concrete. Complete finishing of concrete paving surrounding tiles. Remove concrete from tile surfaces.
5. Clean tiles using methods recommended in writing by manufacturer.

C. Surface-Applied Detectable Warning Tiles:

1. Lay out detectable warning tiles as indicated and mark concrete pavement.
2. Prepare existing paving surface by grinding and cleaning as recommended by manufacturer.

    a. Cut perimeter kerf in existing concrete pavement to receive metal tile flange.

3. Apply adhesive to back of tiles in amounts and pattern recommended by manufacturer, and set tiles in place. Firmly seat tiles in adhesive bed, eliminating air pockets and establishing full adhesion to pavement. If necessary, temporarily apply weight to tiles to ensure full contact with concrete.

4. Install anchor devices through face of tiles and into pavement using anchors located as recommended by manufacturer. Set heads of anchors flush with top surface of mat.
5. Mask perimeter of tiles and adjacent concrete, and apply sealant in continuous bead around perimeter of tile installation.
6. Remove masking, adhesive, excess sealant, and soil from exposed surfaces of detectable warning tiles and surrounding concrete pavement using cleaning agents recommended in writing by manufacturer.
7. Protect installed tiles from traffic until adhesive has set.

## 3.4 INSTALLATION OF DETECTABLE WARNING MATS

A. Lay out detectable warning mats as indicated and mark concrete pavement at edges of mats.

B. Prepare existing paving surface by grinding and cleaning as recommended by manufacturer.

C. Apply adhesive to back of mat in amounts and pattern recommended by manufacturer, and set mat in place. Firmly seat mat in adhesive bed, eliminating air pockets and establishing full adhesion to pavement. If necessary, temporarily apply weight to mat to ensure full contact with adhesive.

D. Install anchor devices through face of mat and into pavement using anchors located as recommended by manufacturer. Set heads of anchors flush with mat surface.

E. Mask mat perimeter and adjacent concrete, and apply sealant in continuous bead around perimeter of mat.

F. Remove masking, adhesive, excess sealant, and soil from exposed surfaces of detectable warning mat and surrounding concrete pavement using cleaning agents recommended in writing by manufacturer.

G. Protect installed mat from traffic until adhesive has set.

## 3.5 INSTALLATION OF DETECTABLE WARNING UNIT PAVERS

A. Unit Paver Installation, General:

1. Setting-Bed and Unit Paver Installation: Comply with installation requirements in Section 321400 "Unit Paving."
2. Mix unit 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.
4. Tolerances: Do not exceed 1/4 inch in 10 feet (6 mm in 3 m) from level, or indicated slope, for finished surface of paving.

B. Aggregate Setting-Bed Applications:

1. Place aggregate base, compact by tamping with plate vibrator, and screed to depth indicated.

2. 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 uniform until unit pavers are set and compacted.
3. Treat leveling course with herbicide to inhibit growth of grass and weeds.
4. Set unit 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.
5. 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.
6. 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.

C. Mortar Setting-Bed Applications:

1. Saturate concrete subbase 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 subbase about 15 minutes before placing mortar 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; spread and screed mortar bed to uniform thickness at subgrade elevations required for accurate setting of pavers to finished grades indicated.
4. Mix and place only that amount of mortar bed that can be covered with pavers before initial set. Before placing pavers, cut back, bevel edge, and remove and discard setting-bed material that has reached initial set.
5. Place pavers before initial set of cement occurs. Immediately before placing pavers on mortar bed, apply uniform 1/16-inch- (1.5-mm-) thick bond coat to mortar bed or to back of each paver with a flat trowel.
6. 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.
7. Spaced Joint Widths: Provide [**3/8-inch (10-mm)**] [**1/2-inch (13-mm)**] nominal joint width with variations not exceeding plus or minus [**1/16 inch (1.5 mm)**] [**1/8 inch (3 mm)**].
8. Grouted Joints: Grout paver joints complying with ANSI A108.10. 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. Tool exposed joints slightly concave when thumbprint hard.
    c. Cure grout by maintaining in a damp condition for seven days unless otherwise recommended by grout or liquid-latex manufacturer.

9. Remove excess grout from exposed paver surfaces; wash and scrub clean.
10. Protect installation from traffic until grout has set.

## 3.6 CLEANING AND PROTECTION

A. Remove and replace tactile warning surfacing that is broken or damaged or does not comply with requirements in this Section. Remove in complete sections from joint to joint unless

otherwise approved by Architect. Replace using tactile warning surfacing installation methods acceptable to Architect.

B. Protect tactile warning surfacing from damage and maintain free of stains, discoloration, dirt, and other foreign material.

END OF SECTION 32 17 26

# SECTION 32 31 10 - SITE FURNISHINGS

## PART 1 DESCRIPTION

### 1.01 SUMMARY

A. Work under this Section is subject to the requirements of the Contract Documents.

B. Furnish and install all Site Furnishings as shown on the Drawings and as specified herein, including but not limited to the following:

1. Bike racks.
2. Planters.
3. Benches.
4. Excavating holes and placing concrete for bench posts.
5. Precast concrete bollards, including concrete foundation work.
6. Trash Receptacles.

C. Install products and materials (furnished by others) as shown on the Drawings and as specified herein, including but not limited to the following:

### 1.02 REFERENCES:

A. ASTM A 53 -Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

B. ASTM Specification A 615 - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

C. ASTM C 33 - Standard Specification for Concrete Aggregates.

D. ASTM C 150 - Standard Specification for Portland Cement.

E. ASTM C 260 - Standard Specification for Air-Entraining Admixtures for Concrete.

### 1.03 SUBMITTALS:

A. Submit the following

1. Shop Drawings
   a. Information covering fabrication, finish, erection and setting details.
2. Samples and/or Product Data
   a. Product Data:
      (1) Catalogue cuts for all items.

b. Samples:

(1) Samples of materials and full size samples, as requested.

3. Test Reports

a. Submit test reports necessary to show compliance with the Contract Documents.

(1) The precast concrete Manufacturer must perform whatever concrete testing is required to ensure compliance with requirements set forth herein. Precast concrete work with concrete strengths below minimum requirements will not be accepted. Concrete tests performed by the manufacturer must be in accordance with appropriate ASTM Specifications, and copies of the test results must be submitted to the Commissioner.

4. Manufacturer's Certification

a. Submit certification that products meet or exceed the specified requirements.

5. Operation and Maintenance Manuals

a. Provide maintenance instruction.

B. LEED Submittals

1. Product Data for LEED Credit MR 4 and SAM Credit 5.7: For products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content. Include statement indicating costs for each product having recycled content.
2. Product Data for LEED Credit MR 5 and SAM Credit 5.8: For products and materials required to comply with requirements for regional materials, documentation indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.

1.04 QUALITY CONTROL:

A. Contractor Qualifications: Installation of site furnishing must be performed only by a qualified Installer. The term qualified means experienced in performing the Work required by this Section. The qualified installer must have a minimum of five (5) years documented experience on Projects similar in size and scope to this Project. The installer must submit evidence of such qualifications upon request by the Commissioner.

B. Perform Work in accordance with the latest edition, of the appropriate divisions, of the following:

1. ASTM - American Society for Testing and Materials applicable Sections.

1.05 DELIVERY, STORAGE AND HANDLING:

A. Delivery, Storage and Handling - Materials must be stored in strict accordance with the Manufacturer's printed directions, copies of which must be furnished to the Commissioner.

B. Handling - Support precast concrete items during hauling, storage, handling and setting to prevent cracking or staining. Support only at points designed to resist such forces. All damaged or otherwise unsuitable material must be immediately removed from Project site and replaced with new material at no additional cost to the City. Approved sequence for handling during erection must be strictly adhered to.

C. Protect materials against damage from mechanical abuse, plaster, salts, acids, staining and other foreign matter by an approved means during transportation, storage and erection and until completion of construction Work. All unsatisfactory materials must be removed from the premises, and all damaged materials replaced with new materials.

D. Access and Storage Areas

1. All access routes and storage areas must be subject to the approval of the Commissioner in order to reduce interference with Airport Operations.

1.06 WARRANTIES AND GUARANTEES:

A. Any warranty provided by the manufacturer must be provided.

1.07 SPECIAL REQUIREMENTS:

A. Field Measurements: Before proceeding with fabrication of the site furnishings Work, the Installer must verify all dimensions and take such measurements as are required for proper fabrication, installation and erection of the Work.

B. Coordination: Coordinate Work of this Section with related Work specified in the other divisions/sections of the Contract Documents.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

A. Products of one of the following Manufacturers will be acceptable:

1. Bike racks

a. (Consultant will select product.)

2. Planters

a. (Consultant will select product.)

3. Benches

a. (Consultant will select product.)

4. Trash receptacles

a. (Consultant will select product.)

5. Bollards

a. (Consultant will select product.)

## PART 3 EXECUTION

### 3.01 INSPECTION:

A. Before commencing installation, examine substrate surfaces to determine that they are free of conditions which might be detrimental to proper and timely completion of the work. Start of work must indicate acceptance of the substrate.

B. Verify job site conditions prior to delivery and installation of any of the items. Any discrepancies or variations in related work that may affect the proper installation of the items must be corrected to the satisfaction of the Commissioner before any installation work is started.

C. Any precast concrete work that is chipped, cracked or damaged shall be returned to the Manufacturer for replacement, or shall be repaired and restored to the original state to the satisfaction of the Commissioner.

### 3.02 INSTALLATION:

A. Bike Racks

1. Sleeve inserts to receive bike rack posts must be accurately set and secured in place prior to pouring concrete sidewalk slab. Installation must be coordinated with work required under [Section 02714 - Concrete Pavements].

a. Where posts are to be set into existing concrete sidewalk slabs, the concrete stab must be core drilled using a drill of required diameter, with depth of penetration into concrete slab as noted on manufacturer's installation details for setting bike racks. Sleeve inserts must be set and anchored in place with non-shrink premixed non-metallic type grout; Bike Rack posts must be welded or bolted to sleeve inserts with vandal proof bolts.

B. Wood Benches

1. Excavating of holes to receive pedestals for wood benches and placing of concrete for concrete bases must be included as work required under this Section. Coordinate installation with work required under [Section 02714 - Concrete Pavements].
2. Pedestals must be set plumb and bench tops set at height shown on Drawings.

C. Precast Concrete Bollards

1. Precast concrete bollards, must be installed as work required under this Section. Installation must be done by the manufacturer of the precast concrete bollards or by an authorized representative to do the Work.
2. The precast bollards must be erected in true alignment and plumb using proper slings and necessary means of protection during the erection process against damaging edges, arises and exposed surfaces.
3. Any precast concrete work that is chipped, cracked or damaged must be returned to the Manufacturer for replacement, or must be repaired and restored to the original state to the satisfaction of the Commissioner.

3.03 GENERAL CLEAN-UP:

A. All rubbish and debris resulting from the Work of this Section must be collected, removed from the site and disposed of legally.

B. All work areas must be left in a broom clean condition.

END OF SECTION 32 31 10

# SECTION 32 31 13 - CHAIN-LINK FENCES AND GATES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. This Section includes the following:

1. Chain-Link Fences, Exterior and Interior.
2. Gates: Manual, swing.
3. Privacy slats.

B. Related Sections:
1. Division 3 Section “Cast-In-Place Concrete” for requirements of concrete foundations provided under this section.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

a. Fence and gate posts, rails, and fittings.
b. Chain-link fabric, reinforcements, and attachments.
c. Accessories: Privacy slats.
d. Gates and hardware.

B. Shop Drawings: For each type of fence and gate assembly.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include accessories and hardware.

1.4 Samples for Initial Selection: For each type of factory-applied finish. QUALITY ASSURANCE

PART 2 - PRODUCTS

2.1 CHAIN-LINK FENCE FABRIC

A. Steel Wire Fabric:

1. Height: Full-height of fence as indicated on Drawings.
2. Type: Zinc coating.
3. Selvage: Knuckled at both selvages
4. Mesh Size:

a. Standard Mesh: 1-3/ 4 inches (45 mm), wire size 11gage.

2.2 INDUSTRIAL FENCE FRAMING

A. Posts and Rails: Comply with ASTM F 1043 for framing, ASTM F 1083 for Group IC round pipe, and the following:

1. Group: IA, round steel pipe, Schedule 40 or IV, Alternative Design.
2. Fence Height: As indicated on Drawings.
3. Strength Requirement, according to ASTM F 1043:

a. Exterior: Heavy industrial.
b. Interior, Cantilevered from Floor: Heavy Industrial.
c. Interior, top and bottom attached: Light Industrial.

4. Swing Gate Post: According to ASTM F 1184.
5. Coating for Steel Framing: Metallic coating, compatible with fabric coating.

2.3 TENSION WIRE

A. General: Provide horizontal tension wire at bottom of fence fabric, unless bottom rail is indicated.

B. Metallic-Coated Steel Wire: 0.177-inch- (4.5-mm-) diameter, marcelled tension wire complying with ASTM A 817 and ASTM A 824.

1. Metallic Coating: Type III, Zn-5-Al-MM alloy.

2.4 INDUSTRIAL SWING GATES

A. General: Comply with ASTM F 900 for single swing gate types.

1. Metal Pipe and Tubing: Galvanized steel. Comply with ASTM F 1083 and ASTM F 1043 for materials and protective coatings.

B. Frames and Bracing: Fabricate members from round, galvanized steel tubing with outside dimension and weight according to ASTM F 900 and the following:

1. Gate Fabric Height: 2 inches (50 mm) less than adjacent fence height.
2. Leaf Width: 36 inches (914 mm), or as indicated.
3. Frame Members:

    a. 1.90 inches (48 mm) round.

C. Fabrication:

1. Frame Corner Construction: Welded.
2. Design: Rectangular frame arrangement, free of diagonal bracing for gates less than 5 feet width. Provide horizontal stiffening rail at mid-height.
3. Provide lock block where indicated.

D. Hardware:

1. 2 Hinges per leaf 7’-0” or less in height; 1 additional hinge for each 2 feet of added height.
2. Drop-canes for each gate leaf more than 5 feet (1.52 m) wide, and for each inactive leaf of double gates.
3. Latches:

    a. Heavy-duty cast metal, of type permitting operation from both sides of gate. Fabricate latches with integral eye openings for padlocking; padlock accessible from both sides of gate.
    b. At designated gates, provide galvanized welded-steel lock box, 1.75 inches deep and fitted to receive Lockset provided under Section 08710.

## 2.5 FITTINGS

A. General: Comply with ASTM F 626.

B. Finish:

1. Metallic Coating for Pressed Steel or Cast Iron: Not less than 1.2 oz. /sq. ft. zinc.

## 2.6 CAST-IN-PLACE CONCRETE

A. Concrete Mixes: Portland cement concrete meeting requirements of Section 033000 and of 3000 psi compressive strength.

## 2.7 FENCE GROUNDING

A. Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.

1. Material above Finished Grade: Copper.

2. Material on or below Finished Grade: Copper.
3. Bonding Jumpers: Braided copper tape, 1 inch (25 mm) wide, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.

B. Connectors and Grounding Rods: Comply with UL 467.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. General: Install chain-link fencing to comply with ASTM F 567 and more stringent requirements specified.

B. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.

C. Post Setting: Set posts at indicated spacing in concrete footings into firm, undisturbed soil, or attach to slabs with mechanical anchors.

1. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
2. Mechanical Attachment: Use (4) 1/2–inch diameter by 4-inch embed expansion bolts through predrilled welded base plate.

D. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment.

E. Line Posts: Space line posts uniformly at [10 feet (3 m)] <Insert dimension> o.c.

F. Post Bracing and Intermediate Rails: Install according to ASTM F 567. Install braces at end and gate posts and at both sides of corner and pull posts.

G. Tension Wire: Install according to ASTM F 567, maintaining plumb position and alignment of fencing.

H. Top Rail: Install according to ASTM F 567.

I. Bottom Rails: Install, spanning between posts.

J. Chain-Link Fabric: Apply fabric to enclosing framework.

1. Decorative Fabric: Attach as detailed.
2. Standard Fabric: Leave 2 inches (50 mm) between finish grade or surface and bottom selvage, unless otherwise indicated.

K. Tie Wires: Attach wire per ASTM F 626. Bend ends of wire to minimize hazard to individuals and clothing.

L. 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.

## 3.2 GATE INSTALLATION

A. 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.

## 3.3 GROUNDING AND BONDING

A. Fence Grounding: Install at maximum intervals of 500 feet, and at each fenced enclosure around pumps, transformers and other electrical equipment.

1. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at the grounding location.

B. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.

1. Connections: Make connections so possibility of galvanic action or electrolysis is minimized.

C. 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.

END OF SECTION 32 31 13

# SECTION 32 84 00 - PLANTING IRRIGATION

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. Section Includes:

1. Piping.
2. Encasement for piping.
3. Manual valves.
4. Pressure-reducing valves.
5. Automatic control valves.
6. Automatic drain valves.
7. Transition fittings.
8. Dielectric fittings.
9. Miscellaneous piping specialties.
10. Sprinklers.
11. Quick couplers.
12. Drip irrigation specialties.
13. Controllers.
14. Boxes for automatic control valves.

B. Related Sections:

1. Section 220519 "Meters and Gages for Plumbing Piping" for water metering requirements.
2. Section 230923.14 "Flow Instruments" for water metering equipment.

### 1.3 DEFINITIONS

A. Circuit Piping: Downstream from control valves to sprinklers, specialties, and drain valves. Piping is under pressure during flow.

B. Drain Piping: Downstream from circuit-piping drain valves. Piping is not under pressure.

C. ET Controllers: EvapoTranspiration Controllers. Irrigation controllers which use some method of weather based adjustment of irrigation. These adjusting methods include use of historical monthly averages of ET; broadcasting of ET measurements; or use of on-site sensors to track ET.

D. Main Piping: Downstream from point of connection to water distribution piping to, and including, control valves. Piping is under water-distribution-system pressure.

E. 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.

## 1.4 PERFORMANCE REQUIREMENTS

A. Irrigation zone control shall be [**automatic operation with controller and automatic control**] [**manual operation with manual**] valves.

B. 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.

C. Delegated Design: Design 100 percent coverage irrigation system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1. Available land records indicate the following soil conditions:

a. Type: [**Coarse**] [**Medium**] [**Fine**] <**Insert type**>.
b. Texture:

1) Sand: <**Insert number**> percent.
2) Silt: <**Insert number**> percent.
3) Clay: <**Insert number**> percent.

c. Particle Size:

1) Sand: <**Insert number**> mm.
2) Silt: <**Insert number**> mm.
3) Clay: <**Insert number**> mm.

d. Structure: [**Single grained**] [**Granular**] [**Platy**] [**Blocky**] <**Insert structure**>.
e. Density: <**Insert lb/cu. ft. (kg./cu. m)**>.
f. Moisture Content: <**Insert number**> percent.
g. Infiltration Rate: <**Insert gph (L/s)**>.

D. Minimum Working Pressures: The following are minimum pressure requirements for piping, valves, and specialties unless otherwise indicated:

1. Irrigation Main Piping: [**200 psig (1380 kPa)**] <**Insert value**>.
2. Circuit Piping: [**150 psig (1035 kPa)**] <**Insert value**>.

## 1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics,[ **electrical characteristics,**] and furnished specialties and accessories.

B. Wiring Diagrams: For power, signal, and control wiring.

C. 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.

D. Sustainable Design Submittals:

1. <Double click to insert sustainable design text for irrigation control system.>
2. <Double click to insert sustainable design text for submetering submittal.>

## 1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Irrigation systems, drawn to scale, on which components are shown and coordinated with each other, using input from Installers of the items involved. Also include adjustments necessary to avoid plantings and obstructions such as signs and light standards.

B. Qualification Data: For qualified Installer.

C. Zoning Chart: Show each irrigation zone and its control valve.

D. Controller Timing Schedule: Indicate timing settings for each automatic controller zone.

E. Field quality-control reports.

## 1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For [**sprinklers**] [**controllers**] [**and**] [**automatic control valves**] to include in operation and maintenance manuals.

## 1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Impact Sprinklers: Equal to <**Insert number**> percent of amount installed for each type and size indicated, but no fewer than <**Insert number**> units.
2. Spray Sprinklers: Equal to <**Insert number**> percent of amount installed for each type and size indicated, but no fewer than <**Insert number**> units.
3. Bubblers: Equal to <**Insert number**> percent of amount installed for each type indicated, but no fewer than <**Insert number**> units.
4. Emitters: Equal to <**Insert number**> percent of amount installed for each type indicated, but no fewer than <**Insert number**> units.
5. Drip-Tube System Tubing: Equal to <**Insert number**> percent of total length installed for each type and size indicated, but not less than [**100 feet (30 m)**] [**500 feet (152 m)**] <**Insert value**>.
6. Soaker Tubes: Equal to <**Insert number**> percent of total length installed for each type and size indicated, but not less than [**50 feet (15.2 m)**] [**100 feet (30 m)**] <**Insert value**>.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers that include a [**certified irrigation designer qualified by The Irrigation Association**] [**Professional Class member of the American Society of Irrigation Consultants**] [**Professional Technical Class member of the American Society of Irrigation Consultants**] <**Insert qualifications**>.

B. 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.

1.10 DELIVERY, STORAGE, AND HANDLING

A. 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.

B. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.11 PROJECT CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:

1. Notify [**Architect**] [**Construction Manager**] [**Owner**] no fewer than [**two**] <**Insert number**> days in advance of proposed interruption of water service.
2. Do not proceed with interruption of water service without [**Architect's**] [**Construction Manager's**] [**Owner's**] written permission.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. 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.

B. Galvanized-Steel Pipe: ASTM A 53/A 53M, Standard Weight, Type E, Grade B.

1. 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.
2. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
3. 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.
4. Cast-Iron Flanges: ASME B16.1, Class 125.

C. Ductile-Iron Pipe with Mechanical Joints: AWWA C151, with mechanical-joint bell and spigot ends.

1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.

    a. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

D. Ductile-Iron Pipe with Push-on Joint: AWWA C151, with push-on-joint bell and spigot ends.

1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.

    a. Gaskets: AWWA C111, rubber.

E. Soft Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B), water tube, annealed temper.

1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end.
3. 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.

F. 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.

1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end.
3. 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.

G. PE Pipe with Controlled ID: ASTM F 771, PE 3408 compound; [**SIDR 11.5**] [**and**] [**SIDR 15**].

1. Insert Fittings for PE Pipe: ASTM D 2609, nylon or propylene plastic with barbed ends. Include bands or other fasteners.

H. PE Pipe with Controlled OD: ASTM F 771, PE 3408 compound, SDR 11.

1. PE Butt, Heat-Fusion Fittings: ASTM D 3261.
2. PE Socket-Type Fittings: ASTM D 2683.

I. 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)**] [**200 psig (1380 kPa)**].

1. PE Butt, Heat-Fusion Fittings: ASTM D 3261.
2. PE Socket-Type Fittings: ASTM D 2683.

J. PVC Pipe: ASTM D 1785, PVC 1120 compound, [**Schedule 40**] [**Schedule 80**] [**Schedules 40 and 80**].

1. PVC Socket Fittings: ASTM D 2466, [**Schedule 40**] [**Schedule 80**] [**Schedules 40 and 80**].

2. PVC Threaded Fittings: ASTM D 2464, Schedule 80.
3. PVC Socket Unions: Construction similar to MSS SP-107, except both headpiece and tailpiece shall be PVC with socket ends.

K. PVC Pipe, Pressure Rated: ASTM D 2241, PVC 1120 compound, [**SDR 21**] [**and**] [**SDR 26**].

1. PVC Socket Fittings: ASTM D 2467, Schedule 80.
2. PVC Socket Unions: Construction similar to MSS SP-107, except both headpiece and tailpiece shall be PVC with socket or threaded ends.

## 2.2 PIPING JOINING MATERIALS

A. 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.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

F. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

## 2.3 ENCASEMENT FOR PIPING

A. Standard: ASTM A 674 or AWWA C105.

B. Form: [**Sheet**] [**Sheet or tube**] [**Tube**].

C. Material: [**LLDPE film of 0.008-inch (0.20-mm)**] [**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)**] [**High-density, cross-laminated PE film of 0.004-inch (0.10-mm)**] minimum thickness.

D. Color: [**Black**] [**or**] [**Natural**] <**Insert color**>.

## 2.4 MANUAL VALVES

A. Curb Valves:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

a. Standard: AWWA C800.

b. NPS 1 (DN 25) and Smaller Pressure Rating: [**100 psig (690 kPa) minimum**] [**150 psig (1035 kPa)**].
c. NPS 1-1/4 to NPS 2 (DN 32 to DN 50) Pressure Rating: [**80 psig (550 kPa) minimum**] [**150 psig (1035 kPa)**].
d. Body Material: Brass or bronze with ball or ground-key plug.
e. End Connections: Matching piping.
f. Stem: With wide-tee head.

B. Curb-Valve Casing:

1. Standard: Similar to AWWA M44 for cast-iron valve casings.
2. Top Section: Telescoping, of length required for depth of burial of curb valve.
3. Barrel: Approximately 3-inch (75-mm) diameter.
4. Plug: With lettering "WATER."
5. Bottom Section: With base of size to fit over valve.
6. Base Support: Concrete collar[ **or wood frame**].

C. Shutoff Rods for Curb-Valve Casings: Furnish [**one**] [**two**] <**Insert number**> 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.

D. Brass Ball Valves:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Two piece.
e. Body Material: Forged brass.
f. Ends: Threaded or solder joint if indicated.
g. Seats: PTFE or TFE.
h. Stem: Brass.
i. Ball: Chrome-plated brass.
j. Port: Full[ **or regular, but not reduced**].

E. Bronze Ball Valves:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded or solder joint if indicated.
g. Seats: PTFE or TFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.

j. Port: Full[ **or regular, but not reduced**].

F. Iron Ball Valves:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

a. Standard: MSS SP-72.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Split body.
d. Body Material: ASTM A 126, gray iron.
e. Ends: Flanged.
f. Seats: PTFE or TFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel.
i. Port: Full.

G. Plastic Ball Valves:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

a. Standard: MSS SP-122.
b. Pressure Rating: [**125 psig (860 kPa) minimum**] [**150 psig (1035 kPa)**].
c. Body Material: PVC.
d. Type: Union.
e. End Connections: Socket or threaded.
f. Port: Full.

H. Bronze Gate Valves:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

a. Standard: MSS SP-80, Type 2.
b. Class: 125.
c. CWP Rating: 200 psig (1380 kPa).
d. Body Material: ASTM B 62 bronze with integral seat and screw-in bonnet.
e. Ends: Threaded or solder joint.
f. Stem: Bronze, nonrising.
g. Disc: Solid wedge; bronze.
h. Packing: Asbestos free.
i. Handwheel: Malleable iron, bronze, or aluminum.

I. Iron Gate Valves, Resilient Seated:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

a. Standard: AWWA C509.
b. Pressure Rating: [**200 psig (1380 kPa)**] [**250 psig (1725 kPa)**] minimum.

c. Body Material: Ductile or gray iron with bronze trim.
d. End Connections: Mechanical joint or push-on joint.
e. Interior Coating: Comply with AWWA C550.
f. Body Design: Nonrising stem.
g. Operator: Stem nut.
h. Disc: Solid wedge with resilient coating.

J. Iron Gate Valve Casings:

1. Standard: AWWA M44 for cast-iron valve casings.
2. Top Section: Adjustable extension of length required for depth of burial of valve.
3. Barrel: Approximately 5-inch (125-mm) diameter.
4. Plug: With lettering "WATER."
5. Bottom Section: With base of size to fit over valve.
6. Base Support: Concrete collar[ **or wood frame**].

K. Operating Wrenches for Iron Gate Valve Casings: Furnish [**one**] [**two**] <**Insert number**> 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.

L. Iron Gate Valves, NRS:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

a. Standard: MSS SP-70, Type I.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Material: ASTM A 126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: All bronze.
f. Disc: Solid wedge.
g. Packing and Gasket: Asbestos free.

M. Iron Gate Valves, OS&Y:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

a. Standard: MSS SP-70, Type I.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Material: ASTM A 126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: All bronze.
f. Disc: Solid wedge.
g. Packing and Gasket: Asbestos free.

## 2.5 PRESSURE-REDUCING VALVES

A. Water Regulators:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

    a. Standard: ASSE 1003.
    b. 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).
    c. Pressure Rating: Initial pressure of 150 psig (1035 kPa).
    d. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).

3. Capacities and Characteristics:

    a. Size: <**Insert NPS (DN)**>.
    b. Design Flow Rate: <**Insert gpm (L/s)**>.
    c. Design Inlet Pressure: <**Insert psig (kPa)**>.
    d. Design Outlet Pressure Setting: <**Insert psig (kPa)**>.

B. Water Control Valves:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Pilot-operation, diaphragm-type, single-seated main water control valve. Include small pilot control valve, restrictor device, specialty fittings, and sensor piping.

    a. Main Valve Body: Cast- or ductile-iron body with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body.
    b. Pattern: [**Angle**] [**Globe**]-valve design.
    c. Trim: Stainless steel.
    d. Pressure Rating: Initial pressure of 150 psig (1035 kPa) minimum.
    e. End Connections: Threaded for NPS 2 (DN 50) and smaller; [**flanged**] <**Insert type**> for NPS 2-1/2 (DN 65) and larger.

3. Capacities and Characteristics:

    a. Size: <**Insert NPS (DN)**>.
    b. Design Flow Rate: <**Insert gpm (L/s)**>.
    c. Design Inlet Pressure: <**Insert psig (kPa)**>.
    d. Design Outlet Pressure Setting: <**Insert psig (kPa)**>.

## 2.6 AUTOMATIC CONTROL VALVES

A. Bronze, Automatic Control Valves:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Cast-bronze body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid.

B. Plastic, Automatic Control Valves:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Description: Molded-plastic body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid.

## 2.7 AUTOMATIC DRAIN VALVES

A. 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).

## 2.8 TRANSITION FITTINGS

A. General Requirements: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

B. Transition Couplings:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: AWWA C219, metal sleeve-type coupling for underground pressure piping.

C. Plastic-to-Metal Transition Fittings:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. 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.

D. Plastic-to-Metal Transition Unions:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. 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.

## 2.9 DIELECTRIC FITTINGS

A. 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.

B. Dielectric Unions:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Factory-fabricated union, NPS 2 (DN 50) and smaller.

a. Pressure Rating: [**150 psig (1035 kPa) minimum**] [**250 psig (1725 kPa)**] at 180 deg F (82 deg C).
b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded ferrous.

C. Dielectric Flanges:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Factory-fabricated, bolted, companion-flange assembly, NPS 2-1/2 to NPS 4 (DN 65 to DN 100) and larger.

    a. Pressure Rating: [**150 psig (1035 kPa) minimum**] [**175 psig (1200 kPa) minimum**] [**300 psig (2070 kPa)**].
    b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Kits:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Nonconducting materials for field assembly of companion flanges, NPS 2-1/2 (DN 65) and larger.

    a. Pressure Rating: [**150 psig (1035 kPa) minimum**] <**Insert value**>.
    b. Gasket: Neoprene or phenolic.
    c. Bolt Sleeves: Phenolic or polyethylene.
    d. Washers: Phenolic with steel backing washers.

E. Dielectric Couplings:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Galvanized-steel coupling.

    a. Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
    b. End Connections: Female threaded.
    c. Lining: Inert and noncorrosive, thermoplastic lining.

F. Dielectric Nipples:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Electroplated steel nipple complying with ASTM F 1545.

    a. Pressure Rating: [**300 psig (2070 kPa) at 225 deg F (107 deg C)**] <**Insert values**>.
    b. End Connections: Male threaded or grooved.
    c. Lining: Inert and noncorrosive, propylene.

## 2.10 MISCELLANEOUS PIPING SPECIALTIES

A. 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.

B. 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.

## 2.11 SPRINKLERS

A. General Requirements: Designed for uniform coverage over entire spray area indicated at available water pressure.

B. Metal, Exposed, Impact-Drive Rotary Sprinklers:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

    a. Construction: Brass and other corrosion-resistant metals.
    b. Mounting: Aboveground, exposed on riser.

3. Capacities and Characteristics:

    a. Flow: <**Insert gpm (L/s)**>.
    b. Arc: [**Full**] [**Half**] [**Quarter**] <**Insert arc**> circle.
    c. Radius: <**Insert feet (m)**>.
    d. Inlet: [**NPS 1/2 (DN 15)**] [**NPS 1/2 or NPS 3/4 (DN 15 or DN 20)**] [**NPS 3/4 (DN 20)**] <**Insert value**>.

C. Plastic, Exposed, Impact-Drive Rotary Sprinklers:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

    a. Construction: ABS and corrosion-resistant metals.
    b. Mounting: Aboveground, exposed on riser.

3. Capacities and Characteristics:

    a. Flow: <**Insert gpm (L/s)**>.
    b. Arc: [**Full**] [**Half**] [**Quarter**] <**Insert arc**> circle.
    c. Radius: <**Insert feet (m)**>.
    d. Inlet: [**NPS 1/2 (DN 15)**] [**NPS 1/2 or NPS 3/4 (DN 15 or DN 20)**] [**NPS 3/4 (DN 20)**] <**Insert size**>.

D. Plastic, Pop-up, Gear-Drive Rotary Sprinklers:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

    a. Body Material: ABS.
    b. Nozzle: [**ABS**] [**Brass**].
    c. Retraction Spring: Stainless steel.
    d. Internal Parts: Corrosion resistant.

3. Capacities and Characteristics:

    a. Flow: <**Insert gpm (L/s)**>.

b. Pop-up Height: [**4 inches (100 mm)**]<**Insert inches (mm)**> aboveground to nozzle.
c. Arc: [**Full**] [**Half**] [**Quarter**] <**Insert arc**> circle.
d. Radius: <**Insert feet (m)**>.
e. Inlet: [**NPS 1/2 (DN 15)**] [**NPS 1/2 or NPS 3/4 (DN 15 or DN 20)**] [**NPS 3/4 (DN 20)**].

E. Metal, Pop-up, Impact-Drive Rotary Sprinklers:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

a. Case: Brass.
b. Body Material: Brass.
c. Pop-up Height: [**4 inches (100 mm)**][**Approximately 3 inches (75 mm)**] <**Insert value**> aboveground to nozzle.
d. Sprinkler Construction: Brass and other corrosion-resistant metals.

3. Capacities and Characteristics:

a. Flow: <**Insert gpm (L/s)**>.
b. Arc: [**Full**] [**Half**] [**Quarter**] <**Insert arc**> circle.
c. Radius: <**Insert feet (m)**>.
d. Inlet: [**NPS 3/4 (DN 20)**] [**NPS 1-1/4 (DN 32)**].

F. Plastic, Pop-up, Impact-Drive Rotary Sprinklers:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

a. Case: ABS.
b. Pop-up Height: [**4 inches (100 mm)**][**Approximately 3 inches (75 mm)**] <**Insert value**> aboveground to nozzle.
c. Sprinkler Construction: ABS and other corrosion-resistant metals.

3. Capacities and Characteristics:

a. Nozzle: [**ABS**] [**Brass**].
b. Flow: <**Insert gpm (L/s)**>.
c. Arc: [**Full**] [**Half**] [**Quarter**] <**Insert arc**> circle.
d. Radius: <**Insert feet (m)**>.
e. Inlet: [**NPS 3/4 (DN 20)**] [**NPS 1-1/4 (DN 32)**].

G. Metal, Surface Spray Sprinklers:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

a. Body Material and Flange: Brass.
b. Nozzle: Brass.
c. Pattern: Fixed, with flow adjustment.

3. Capacities and Characteristics:

   a. Flow: <**Insert gpm (L/s)**>.
   b. Arc: [**Full**] [**Half**] [**Quarter**] <**Insert arc**> circle.
   c. Radius: <**Insert feet (m)**>.
   d. Inlet: [**NPS 1/2 (DN 15)**] [**NPS 1/2 or NPS 3/4 (DN 15 or DN 20)**] [**NPS 3/4 (DN 20)**].

H. Plastic, Surface Spray Sprinklers:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

   a. Body Material and Flange: ABS.
   b. Pattern: Fixed, with flow adjustment.

3. Capacities and Characteristics:

   a. Nozzle: [**ABS**] [**Brass**].
   b. Flow: <**Insert gpm (L/s)**>.
   c. Arc: [**Full**] [**Half**] [**Quarter**] <**Insert arc**> circle.
   d. Radius: <**Insert feet (m)**>.
   e. Inlet: [**NPS 1/2 (DN 15)**] [**NPS 1/2 or NPS 3/4 (DN 15 or DN 20)**] [**NPS 3/4 (DN 20)**].

I. Metal, Surface, Pop-up Spray Sprinklers:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

   a. Body Material and Flange: Brass.
   b. Nozzle: Brass.
   c. Pattern: Fixed, with flow adjustment.

3. IgCC requires a minimum pop-up height of 4 inches (100 mm).Capacities and Characteristics:

   a. Pop-up Height: [**4 inches (100 mm)**] [**1-1/4 or 1-1/2 inches (32 or 38 mm)**] [**1-3/4 or 2 inches (44 or 51 mm)**] <**Insert value**>.
   b. Flow: <**Insert gpm (L/s)**>.
   c. Arc: [**Full**] [**Half**] [**Quarter**] <**Insert arc**> circle.
   d. Radius: <**Insert feet (m)**>.
   e. Inlet: [**NPS 1/2 (DN 15)**] [**NPS 1/2 or NPS 3/4 (DN 15 or DN 20)**] [**NPS 3/4 (DN 20)**].

J. Plastic, Surface, Pop-up Spray Sprinklers:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

   a. Body Material and Flange: ABS.

b. Pattern: Fixed, with flow adjustment.

3. Capacities and Characteristics:

a. Pop-up Height: [**4 inches (100 mm)**] [**1-1/4 or 1-1/2 inches (32 or 38 mm)**] [**1-3/4 or 2 inches (44 or 51 mm)**] <**Insert value**>.
b. Nozzle: [**ABS**] [**Brass**].
c. Flow: <**Insert gpm (L/s)**>.
d. Arc: [**Full**] [**Half**] [**Quarter**] <**Insert arc**> circle.
e. Radius: <**Insert feet (m)**>.
f. Inlet: [**NPS 1/2 (DN 15)**] [**NPS 1/2 or NPS 3/4 (DN 15 or DN 20)**] [**NPS 3/4 (DN 20)**].

K. Plastic, Pop-up Spray Sprinklers:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

a. Body Material: ABS.
b. Nozzle: [**ABS**] [**Brass**].
c. Retraction Spring: Stainless steel.
d. Internal Parts: Corrosion resistant.
e. Pattern: Fixed, with flow adjustment.

3. Capacities and Characteristics:

a. Nozzle: [**ABS**] [**Brass**].
b. Flow: <**Insert gpm (L/s)**>.
c. Pop-up Height: [**4 inches (100 mm)**] <**Insert inches (mm)**> aboveground to nozzle.
d. Arc: [**Full**] [**Half**] [**Quarter**] <**Insert arc**> circle.
e. Radius: <**Insert feet (m)**>.
f. Inlet: [**NPS 1/2 (DN 15)**] [**NPS 1/2 or NPS 3/4 (DN 15 or DN 20)**] [**NPS 3/4 (DN 20)**].

L. Metal Shrub Sprinklers:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

a. Body Material: Brass.
b. Nozzle: Brass.
c. Pattern: Fixed, with flow adjustment.

3. Capacities and Characteristics:

a. Configuration: <**Insert description**>.
b. Flow: <**Insert gpm (L/s)**>.
c. Arc: [**Full**] [**Half**] [**Quarter**] <**Insert arc**> circle.
d. Radius: <**Insert feet (m)**>.
e. Mounting Height: <**Insert inches (mm)**> aboveground to nozzle.

f. Inlet: [**NPS 1/2 (DN 15)**] [**NPS 1/2 or NPS 3/4 (DN 15 or DN 20)**] [**NPS 3/4 (DN 20)**].

M. Plastic Shrub Sprinklers:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description:

a. Body Material: ABS or other plastic.
b. Pattern: Fixed, with flow adjustment.

3. Capacities and Characteristics:

a. Configuration: <**Insert description**>.
b. Flow: <**Insert gpm (L/s)**>.
c. Arc: [**Full**] [**Half**] [**Quarter**] <**Insert arc**> circle.
d. Radius: <**Insert feet (m)**>.
e. Mounting Height: <**Insert inches (mm)**> aboveground to nozzle.
f. Inlet: [**NPS 1/2 (DN 15)**] [**NPS 1/2 or NPS 3/4 (DN 15 or DN 20)**] [**NPS 3/4 (DN 20)**].

## 2.12 QUICK COUPLERS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. 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.

1. Locking-Top Option: Vandal-resistant locking feature. Include [**one**] [**two**] <**Insert number**> matching key(s).

## 2.13 DRIP IRRIGATION SPECIALTIES

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Freestanding Emitters: Device to deliver water at approximately 20 psig (138 kPa).

1. Body Material: PE or vinyl, with flow control.
2. Riser to Emitter: PE or PVC flexible tubing.
3. Capacities and Characteristics:

a. Flow: [**1/2 gph (1.9 L/h)**] [**1 gph (3.8 L/h)**] [**2 gph (7.6 L/h)**] <**Insert value**> at approximately 20 psig (138 kPa).
b. Tubing: PE or PVC; 1/8-inch (3-mm) minimum ID.
c. Mounting Height: <**Insert dimension**> aboveground to nozzle.

C. Manifold Emitter Systems: Manifold with tubing and emitters.

1. Manifold: With multiple outlets to deliver water to emitters.

    a. Body Material: Plastic.
    b. Outlet Caps: Plastic, for outlets without installed tubing.
    c. Operation: Automatic pressure compensating.

2. Tubing: PE or PVC; 1/8-inch (3-mm) minimum ID.
3. Emitter: Device to deliver water at approximately 20 psig (138 kPa).

    a. Body Material: PE or vinyl, with flow control.

4. Capacities and Characteristics:

    a. Manifold:

        1) Design Flow: <**Insert gph (L/h)**>.
        2) Number of Outlets: [**Four**] [**Six**] <**Insert number**>.

    b. Emitter No.: <**Insert number**>.

        1) Flow: [**1/2 gph (1.9 L/h)**] [**1 gph (3.8 L/h)**] [**2 gph (7.6 L/h)**] <**Insert value**> at approximately 20 psig (138 kPa).
        2) Mounting Height: [**At ground**] [**As indicated**] <**Insert dimension**>.

D. Multiple-Outlet Emitter Systems: Emitter with tubing and button-type outlets.

1. Emitter: With multiple outlets to deliver water to remote outlets.

    a. Body Material: Plastic, with flow control.
    b. Outlet Caps: Plastic, for outlets without installed tubing.
    c. Operation: Automatic pressure compensating.
    d. Emitters: Devices to deliver water at approximately 20 psig (138 kPa.)

2. Tubing: PE or PVC; 1/8-inch (3-mm) minimum ID.
3. Capacities and Characteristics:

    a. Emitter:

        1) Flow: [**1/2 gph (1.9 L/h)**] [**1 gph (3.8 L/h)**] [**2 gph (7.6 L/h)**] <**Insert value**>.
        2) Number of Outlets: [**Four**] [**Six**] <**Insert number**>.

    b. Button-Type Outlet No.: <**Insert number**>.

        1) Mounting Height: [**At ground**] [**As indicated**] <**Insert dimension**>.

E. Drip Tubes with Direct-Attached Emitters:

1. Tubing: Flexible PE or PVC with plugged end.
2. Emitters: Devices to deliver water at approximately 20 psig (138 kPa).

    a. Body Material: PE or vinyl, with flow control.

b. Mounting: Inserted into tubing at set intervals.

3. Capacities and Characteristics:

a. Tubing Size: [**NPS 1/2 (DN 15)**] [**NPS 3/4 (DN 20)**] [**NPS 1 (DN 25)**] <**Insert value**>.
b. Length: <**Insert inches (mm)**>.
c. Emitter Spacing: <**Insert inches (mm)**>.
d. Emitter Flow: [**1/2 gph (1.9 L/h)**] [**1 gph (3.8 L/h)**] [**2 gph (7.6 L/h)**] <**Insert value**>.

F. Drip Tubes with Remote Discharge:

1. Tubing: Flexible PE or PVC with plugged end.
2. Emitters: Devices to deliver water at approximately 20 psig (138 kPa).

a. Body Material: PE or vinyl, with flow control.
b. Mounting: Inserted into tubing at set intervals.

3. Capacities and Characteristics:

a. Tubing Size: [**NPS 1/2 (DN 15)**] [**NPS 3/4 (DN 20)**] [**NPS 1 (DN 25)**] <**Insert value**>.
b. Length: <**Insert inches (mm)**>.
c. Emitter Spacing: <**Insert inches (mm)**>.
d. Emitter Flow: [**1/2 gph (1.9 L/h)**] [**1 gph (3.8 L/h)**] [**2 gph (7.6 L/h)**] <**Insert value**>.
e. Branch Tubing Size: [**NPS 1/4 (DN 8)**] <**Insert value**> with button-type outlet.
f. Branch Tubing Length: <**Insert inches (mm)**>.

G. Off-Ground Supports: Plastic stakes.

H. 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).

I. Filter Units: Brass or plastic housing, with corrosion-resistant internal parts; of size and capacity required for devices downstream from unit.

J. Air Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.

K. Vacuum Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.

## 2.14 CONTROLLERS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Description:

1. Controller Stations for Automatic Control Valves: Each station is variable from approximately [**5 to 60**] <**Insert numbers**> minutes. Include switch for manual or automatic operation of each station.
2. Exterior Control Enclosures: NEMA 250, Type 4, weatherproof, with locking cover and [**two**] <**Insert number**> matching keys; include provision for grounding.

    a. Body Material: [**Enameled-steel sheet metal**] [**Stainless-steel sheet metal**] [**Molded plastic**].
    b. Mounting: [**Freestanding type for concrete base**] [**Surface type for wall**].

3. Interior Control Enclosures: NEMA 250, Type 12, dripproof, with locking cover and [**two**] <**Insert number**> matching keys.

    a. Body Material: [**Enameled-steel sheet metal**] [**Stainless-steel sheet metal**] [**Molded plastic**].
    b. Mounting: [**Freestanding type for concrete base**] [**Surface type for wall**].

4. Control Transformer: 24-V secondary, with primary fuse.
5. 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.

    a. Manual or Semiautomatic Operation: Allows this mode without disturbing preset automatic operation.
    b. Nickel-Cadmium Battery and Trickle Charger: Automatically powers timing device during power outages.
    c. Surge Protection: Metal-oxide-varistor type on each station and primary power.

6. Moisture Sensor: Adjustable from one to seven days, to shut off water flow during rain.
7. Smart Controllers: Use ET, tested in accordance with IA SWAT Climatological Based Controllers 8th Draft Testing Protocol and compliant with ASHRAE Standard 189.1.
8. Wiring: UL 493, Type UF multiconductor, with solid-copper conductors; insulated cable; suitable for direct burial.

    a. Feeder-Circuit Cables: No. 12 AWG minimum, between building and controllers.
    b. 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.
    c. Splicing Materials: Manufacturer's packaged kit consisting of insulating, spring-type connector or crimped joint and epoxy resin moisture seal; suitable for direct burial.

9. 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.

## 2.15 BOXES FOR AUTOMATIC CONTROL VALVES

A. Plastic Boxes:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.

    a. Size: As required for valves and service.
    b. Shape: [**Round**] [**Square**] [**Rectangular**].
    c. Sidewall Material: [**PE**] [**PE, ABS, or FRP**] <**Insert material**>.
    d. Cover Material: [**PE**] [**PE, ABS, or FRP**] <**Insert material**>.

        1) Lettering: "[**VALVE BOX**] [**IRRIGATION**] <**Insert lettering**>."

B. Polymer-Concrete Boxes:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.

    a. Size: As required for valves and service.
    b. Shape: [**Round**] [**Square**] [**Rectangular**].
    c. Sidewall Material: Polymer concrete with lateral and vertical sidewall design loading of [**5000 lb (2268 kg)**] [**10,000 lb (4536 kg)**] [**15,000 lb (6800 kg)**] minimum over 10 by 10 inches (254 by 254 mm) square.
    d. Cover Material: [**Polymer concrete**] [**Reinforced polymer concrete**] <**Insert material**> with cover design loading of [**5000 lb (2268 kg)**] [**10,000 lb (4536 kg)**] [**15,000 lb (6800 kg)**] minimum over 10 by 10 inches (254 by 254 mm) square.

        1) Lettering: "[**VALVE BOX**] [**IRRIGATION**] <**Insert lettering**>."

C. Drainage Backfill: Cleaned gravel or crushed stone, graded from 3/4 inch (19 mm) minimum to 3 inches (75 mm) maximum.

## PART 3 - EXECUTION

### 3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

B. Install warning tape directly above pressure piping, [**12 inches (300 mm)**] <**Insert value**> below finished grades, except 6 inches (150 mm) below subgrade under pavement and slabs.

C. Drain Pockets: Excavate to sizes indicated. Backfill with cleaned gravel or crushed stone, graded from [**3/4 to 3 inches (19 to 75 mm)**] <**Insert value**>, to [**12 inches (300 mm)**] <**Insert value**> below grade. Cover gravel or crushed stone with sheet of asphalt-saturated felt and backfill remainder with excavated material.

D. Provide minimum cover over top of underground piping according to the following:

1. Irrigation Main Piping: Minimum depth of [**36 inches (900 mm)**] <**Insert value**> below finished grade, or not less than [**18 inches (450 mm)**] <**Insert value**> below average local frost depth, whichever is deeper.
2. Circuit Piping: [**12 inches (300 mm)**] <**Insert value**>.
3. Drain Piping: [**12 inches (300 mm)**] <**Insert value**>.
4. Sleeves: [**24 inches (600 mm)**] <**Insert value**>.

## 3.2 PREPARATION

A. Set stakes to identify locations of proposed irrigation system. Obtain Architect's approval before excavation.

## 3.3 PIPING INSTALLATION

A. Location and Arrangement: Drawings indicate location and arrangement of piping systems. Install piping as indicated unless deviations are approved on Coordination Drawings.

B. Install piping at minimum uniform slope of 0.5 percent down toward drain valves.

C. Install piping free of sags and bends.

D. Install groups of pipes parallel to each other, spaced to permit valve servicing.

E. Install fittings for changes in direction and branch connections.

F. Install unions adjacent to valves and to final connections to other components with NPS 2 (DN 50) or smaller pipe connection.

G. Install flanges adjacent to valves and to final connections to other components with NPS 2-1/2 (DN 65) or larger pipe connection.

H. Install underground thermoplastic piping according to ASTM D 2774[ **and ASTM F 690**].

I. Install expansion loops in control-valve boxes for plastic piping.

J. Lay piping on solid subbase, uniformly sloped without humps or depressions.

K. Install ductile-iron piping according to AWWA C600.

L. 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.

M. 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.

N. Water Hammer Arresters: Install between connection to building main and circuit valves aboveground or in control-valve boxes.

O. Install piping in sleeves under parking lots, roadways, and sidewalks.

P. Install sleeves made of [**Schedule 40**] [**Schedule 80**] PVC pipe and socket fittings, and solvent-cemented joints.

Q. Install transition fittings for plastic-to-metal pipe connections according to the following:

1. Underground Piping:

a. NPS 1-1/2 (DN 40) and Smaller: Plastic-to-metal transition fittings.
b. NPS 2 (DN 50) and Larger: AWWA transition couplings.

2. Aboveground Piping:

a. NPS 2 (DN 50) and Smaller: Plastic-to-metal transition [**fittings**] [**unions**].
b. NPS 2 (DN 50) and Larger: Use dielectric flange kits with one plastic flange.

R. Install dielectric fittings for dissimilar-metal pipe connections according to the following:

1. Underground Piping:

a. NPS 2 (DN 50) and Smaller: Dielectric coupling or dielectric nipple.
b. NPS 2-1/2 (DN 65) and Larger: Prohibited except in control-valve box.

2. Aboveground Piping:

a. NPS 2 (DN 50) and Smaller: Dielectric union.
b. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Dielectric flange.
c. NPS 5 (DN 125) and Larger: Dielectric flange kit.

3. Piping in Control-Valve Boxes:

a. NPS 2 (DN 50) and Smaller: Dielectric union.
b. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Dielectric flange.
c. NPS 5 (DN 125) and Larger: Dielectric flange kit.

## 3.4 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. 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:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. 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.

D. Flanged Joints: Select rubber gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

E. Ductile-Iron Piping Gasketed Joints: Comply with AWWA C600 and AWWA M41.

F. Copper-Tubing Brazed Joints: Construct joints according to CDA's "Copper Tube Handbook," using copper-phosphorus brazing filler metal.

G. 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.

H. PE Piping Fastener Joints: Join with insert fittings and bands or fasteners according to piping manufacturer's written instructions.

I. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End PE Pipe and Fittings: Use butt fusion.
2. Plain-End PE Pipe and Socket Fittings: Use socket fusion.

J. PVC Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. 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.
3. PVC Nonpressure Piping: Join according to ASTM D 2855.

## 3.5 VALVE INSTALLATION

A. Underground Curb Valves: Install in curb-valve casings with tops flush with grade.

B. Underground Iron Gate Valves, Resilient Seat: Comply with AWWA C600 and AWWA M44. Install in valve casing with top flush with grade.

1. Install valves and PVC pipe with restrained, gasketed joints.

C. Aboveground Valves: Install as components of connected piping system.

D. Pressure-Reducing Valves: Install in boxes for automatic control valves or aboveground between shutoff valves.[ **Install full-size valved bypass.**]

E. Throttling Valves: Install in underground piping in boxes for automatic control valves.

F. Drain Valves: Install in underground piping in boxes for automatic control valves.

## 3.6 SPRINKLER INSTALLATION

A. Install sprinklers after hydrostatic test is completed.

B. Install sprinklers at manufacturer's recommended heights.

C. 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.

## 3.7 DRIP IRRIGATION SPECIALTY INSTALLATION

A. Install freestanding emitters on pipe riser to mounting height indicated.

B. Install manifold emitter systems with tubing to emitters. Plug unused manifold outlets. Install emitters on off-ground supports at height indicated.

C. Install multiple-outlet emitter systems with tubing to outlets. Plug unused emitter outlets. Install outlets on off-ground supports at height indicated.

D. Install drip tubes with direct-attached emitters on ground.

E. Install drip tubes with remote-discharge on ground with outlets on off-ground supports at height indicated.

F. Install off-ground supports of length required for indicated mounted height of device.

G. Install [**application pressure regulators**] [**and**] [**filter units**] in piping near device being protected, and [**aboveground**] [**in control-valve boxes**].

H. Install [**air relief valves**] [**and**] [**vacuum relief valves**] in piping, and [**aboveground**] [**in control-valve boxes**].

## 3.8 AUTOMATIC IRRIGATION-CONTROL SYSTEM INSTALLATION

A. Equipment Mounting: Install interior controllers on [**floor**] [**concrete bases**] [**wall**].

1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Equipment Mounting: Install exterior freestanding controllers on precast concrete bases.

1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. 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.

## 3.9 CONNECTIONS

A. Comply with requirements for piping specified in Section 221113 "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.

B. Install piping adjacent to equipment, valves, and devices to allow service and maintenance.

C. Connect wiring between controllers and automatic control valves.

## 3.10 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on each automatic controller.

1. 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.

C. Warning Tapes: Arrange for installation of continuous, underground, detectable warning tapes over underground piping during backfilling of trenches. See Section 312000 "Earth Moving" for warning tapes.

## 3.11 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

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

C. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, operate controllers and automatic control valves to confirm proper system operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Any irrigation product will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

## 3.12 STARTUP SERVICE

A. [**Engage a factory-authorized service representative to perform**] [**Perform**] startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that controllers are installed and connected according to the Contract Documents.
3. Verify that electrical wiring installation complies with manufacturer's submittal.

## 3.13 ADJUSTING

A. Adjust settings of controllers.

B. Adjust automatic control valves to provide flow rate at rated operating pressure required for each sprinkler circuit.

C. 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)**] <**Insert value**> above, finish grade.

## 3.14 CLEANING

A. Flush dirt and debris from piping before installing sprinklers and other devices.

## 3.15 DEMONSTRATION

A. [**Engage a factory-authorized service representative to train**] [**Train**] Owner's maintenance personnel to adjust, operate, and maintain [**automatic control valves**] [**and**] [**controllers**].

## 3.16 PIPING SCHEDULE

A. Install components having pressure rating equal to or greater than system operating pressure.

B. Piping in control-valve boxes and aboveground may be joined with flanges or unions instead of joints indicated.

C. Aboveground irrigation main piping, [**NPS 4 (DN 100) and smaller**] <**Insert pipe size range**>, shall be[ **one of**] the following:

1. Galvanized-steel pipe and galvanized-steel pipe nipples; galvanized, gray-iron threaded fittings; and threaded joints.
2. [**Type L (Type B)**] [**Type M (Type C)**] hard copper tube, wrought- or cast-copper fittings, and [**brazed**] [**soldered**] joints.
3. [**Schedule 40**] [**Schedule 80**], PVC pipe; socket-type PVC fittings; and solvent-cemented joints.
4. Schedule 80, PVC pipe; Schedule 80, threaded PVC fittings; and threaded joints.

D. Aboveground irrigation main piping, [**NPS 5 (DN 125) and larger**] <**Insert pipe size range**>, shall be[ **one of**] the following:

1. Galvanized-steel pipe and galvanized-steel pipe nipples; galvanized, gray-iron threaded fittings; and threaded joints.
2. [**Schedule 40**] [**Schedule 80**], PVC pipe and socket fittings; and solvent-cemented joints.
3. Schedule 80, PVC pipe; Schedule 80, threaded PVC fittings; and threaded joints.

E. Underground irrigation main piping, [**NPS 4 (DN 100) and smaller**] <**Insert pipe size range**>, shall be[ **one of**] the following:

1. 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.
2. 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.
3. Type L (Type B) soft copper tube, wrought-copper fittings, and brazed joints.
4. NPS 4 (DN 100) PE pressure pipe; PE butt, heat-fusion or socket-type fittings; and heat-fusion joints.
5. [**Schedule 40**] [**Schedule 80**], PVC pipe and socket fittings, and solvent-cemented joints.
6. Schedule 80, PVC pipe; Schedule 80, threaded PVC fittings; and threaded joints.
7. SDR 21, PVC, pressure-rated pipe; Schedule 80, PVC socket fittings; and solvent-cemented joints.

F. Underground irrigation main piping, [**NPS 5 (DN 125) and larger**] <**Insert pipe size range**>, shall be[ **one of**] the following:

1. NPS 6 (DN 150) and larger ductile-iron, mechanical-joint pipe; ductile-iron, mechanical-joint fittings, glands, bolts, and nuts; and gasketed joints.
2. NPS 6 (DN 150) and larger ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings and gaskets; and gasketed joints.
3. PE pressure pipe; PE butt, heat-fusion fittings; and heat-fusion joints.
4. [**Schedule 40**] [**Schedule 80**], PVC pipe and socket fittings; and solvent-cemented joints.
5. SDR 21, PVC, pressure-rated pipe; Schedule 80, PVC socket fittings; and solvent-cemented joints.

G. Circuit piping, [**NPS 2 (DN 50) and smaller**] <**Insert pipe size range**>, shall be[ **one of**] the following:

1. [**SIDR 7**] [**SIDR 9**], PE, controlled ID pipe; insert fittings for PE pipe; and fastener joints.
2. [**DR 9**] [**DR 11**], PE, controlled OD pipe; PE butt, heat-fusion, or PE socket-type fittings; and heat-fusion joints.
3. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
4. SDR 26, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.

H. Circuit piping, [**NPS 2-1/2 to NPS 4 (DN 65 to DN 100)**] <**Insert pipe size range**>, shall be[ **one of**] the following:

1. [**SIDR 7**] [**SIDR 9**], PE, controlled ID pipe; insert fittings for PE pipe; and banded or fastener joints.

2. [**DR 9**] [**DR 11**], 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.
3. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
4. SDR 26, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.

I. Underground Branches and Offsets at Sprinklers and Devices: Schedule 80, PVC pipe; threaded PVC fittings; and threaded joints.

1. Option: Plastic swing-joint assemblies, with offsets for flexible joints, manufactured for this application.

J. Risers to Aboveground Sprinklers and Specialties: [**Type L (Type B)**] [**Type M (Type C)**] hard copper tube, wrought-copper fittings, and [**brazed**] [**soldered**] joints.

K. Risers to Aboveground Sprinklers and Specialties: Schedule 80, PVC pipe and socket fittings; and solvent-cemented joints.

L. Drain piping shall be[ **one of**] the following:

1. SIDR 9, 11.5, or 15, PE, controlled ID pipe; insert fittings for PE pipe; and banded or fastener joints.
2. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
3. SDR 21, 26, or 32.5, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.

## 3.17 VALVE SCHEDULE

A. Underground, Shutoff-Duty Valves: Use the following:

1. NPS 2 (DN 50) and Smaller: Curb valve, curb-valve casing, and shutoff rod.
2. NPS 3 (DN 80) and Larger: Iron gate valve, resilient seated; iron gate valve casing; and operating wrench(es).

B. Aboveground, Shutoff-Duty Valves:

1. NPS 2 (DN 50) and Smaller: [**Brass**] [**Brass or bronze**] [**Bronze**] [**Plastic**] ball valve.
2. NPS 2 (DN 50) and Smaller: Bronze gate valve.
3. NPS 2-1/2 (DN 65) and Larger: Iron ball valve.
4. NPS 2-1/2 (DN 65) and Larger: Iron gate valve, [**NRS**] [**OS&Y**].

C. Throttling-Duty Valves:

1. NPS 2 (DN 50) and Smaller: [**Bronze**] [**Plastic**] automatic control valve.
2. NPS 2 (DN 50) and Smaller: [**Brass**] [**Brass or bronze**] [**Bronze**] [**Plastic**] ball valve.
3. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): [**Bronze**] [**Plastic**] automatic control valve.
4. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): Iron ball valve.

D. Drain Valves:

1. NPS 1/2 and NPS 3/4 (DN 15 and DN 20): Automatic drain valve.
2. NPS 1/2 and NPS 3/4 (DN 15 and DN 20): [**Brass**] [**Brass or bronze**] [**Bronze**] [**Plastic**] ball valve.
3. NPS 1/2 and NPS 3/4 (DN 15 and DN 20): Bronze gate valve.
4. NPS 1 to NPS 2 (DN 25 to DN 50): [**Brass**] [**Brass or bronze**] [**Bronze**] [**Plastic**] ball valve.
5. NPS 1 to NPS 2 (DN 25 to DN 50): Bronze gate valve.

END OF SECTION 32 84 00

# SECTION 32 91 13 - SOIL PREPARATION

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. Section includes planting soils[ **and layered soil assemblies**] specified by composition of the mixes.

B. Related Requirements:

1. Section 129200 "Interior Planters and Artificial Plants" for placing planting soil in planters for live interior plants.
2. Section 129300 "Site Furnishings" for placing planting soil in exterior unit planters.
3. Section 311000 "Site Clearing" for topsoil stripping and stockpiling.
4. Section 321443 "Porous Unit Paving" for placing planting-soil fill in porous paving.
5. Section 329200 "Turf and Grasses" for placing planting soil for turf and grasses.
6. Section 329300 "Plants" for placing planting soil for plantings.
7. Section 329600 "Transplanting" for placing planting soil in tree planting pits.
8. Section 329700 "Vegetated Roof Assemblies" for growing media (soil).

### 1.3 ALLOWANCES

A. [**Preconstruction**] [**and**] [**field quality-control**] testing [**is**] [**are**] part of testing and inspecting allowance.

### 1.4 UNIT PRICES

A. Work of this Section is affected by [**unit prices specified in Section 012200 "Unit Prices."**] <**Insert name of unit price.**>

### 1.5 DEFINITIONS

A. AAPFCO: Association of American Plant Food Control Officials.

B. Backfill: The earth used to replace or the act of replacing earth in an excavation. This can be amended or unamended soil as indicated.

C. CEC: Cation exchange capacity.

D. Compost: The product resulting from the controlled biological decomposition of organic material that has been sanitized through the generation of heat and stabilized to the point that it is beneficial to plant growth.

E. Duff Layer: A surface layer of soil, typical of forested areas, that is composed of mostly decayed leaves, twigs, and detritus.

F. Imported Soil: Soil that is transported to Project site for use.

G. Layered Soil Assembly: A designed series of planting soils, layered on each other, that together produce an environment for plant growth.

H. Manufactured Soil: Soil produced by blending soils, sand, stabilized organic soil amendments, and other materials to produce planting soil.

I. NAPT: North American Proficiency Testing Program. An SSSA program to assist soil-, plant-, and water-testing laboratories through interlaboratory sample exchanges and statistical evaluation of analytical data.

J. Organic Matter: The total of organic materials in soil exclusive of undecayed plant and animal tissues, their partial decomposition products, and the soil biomass; also called "humus" or "soil organic matter."

K. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified as specified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

L. RCRA Metals: Hazardous metals identified by the EPA under the Resource Conservation and Recovery Act.

M. SSSA: Soil Science Society of America.

N. 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.

O. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.

P. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil"; but in disturbed areas such as urban environments, the surface soil can be subsoil.

Q. USCC: U.S. Composting Council.

## 1.6 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at [**Project site**] <**Insert location**>.

## 1.7 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include recommendations for application and use.
2. Include test data substantiating that products comply with requirements.
3. Include sieve analyses for aggregate materials.
4. Material Certificates: For each type of [**imported soil**] [**and**] [**soil amendment and fertilizer**] <**Insert item**> before delivery to the site, according to the following:

a. Manufacturer's qualified testing agency's certified analysis of standard products.
b. Analysis of fertilizers, by a qualified testing agency, made according to AAPFCO methods for testing and labeling and according to AAPFCO's SUIP #25.
c. Analysis of nonstandard materials, by a qualified testing agency, made according to SSSA methods, where applicable.

B. Sustainable Design Submittals:

1. <Double click to insert sustainable design text for regional materials.>

C. Samples: For each bulk-supplied material, [**1-quart (1-L)**] [**1-gal. (4-L)**] <**Insert value**> volume of each in sealed containers labeled with content, source, and date obtained. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of composition, color, and texture.

## 1.8 INFORMATIONAL SUBMITTALS

A. Qualification Data: For each testing agency.

B. Preconstruction Test Reports: For preconstruction soil analyses specified in "Preconstruction Testing" Article.

C. Field quality-control reports.

## 1.9 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent, state-operated, or university-operated laboratory; experienced in soil science, soil testing, and plant nutrition; with the experience and capability to conduct the testing indicated; and that specializes in types of tests to be performed.

1. Laboratories: Subject to compliance with requirements, [**provide testing by the following**] [**provide testing by one of the following**]:

a. <**Insert laboratory's name and address**>.

2. Multiple Laboratories: At Contractor's option, work may be divided among qualified testing laboratories specializing in physical testing, chemical testing, and fertility testing.

1.10 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: [**Owner will engage**] [**Engage**] a qualified testing agency to perform preconstruction soil analyses on [**existing, on-site soil**] [**imported soil**] <**Insert item**>.

1. Notify Architect [**seven**] <**Insert number**> days in advance of the dates and times when laboratory samples will be taken.

B. Preconstruction Soil Analyses: For each unamended soil type, perform testing on soil samples and furnish soil analysis and a written report containing soil-amendment and fertilizer recommendations by a qualified testing agency performing the testing according to "Soil-Sampling Requirements" and "Testing Requirements" articles.

1. Have testing agency identify and label samples and test reports according to sample collection and labeling requirements.

1.11 SOIL-SAMPLING REQUIREMENTS

A. General: Extract soil samples according to requirements in this article.

B. Sample Collection and Labeling: Have samples taken and labeled by [**Owner**] [**Contractor in presence of Architect**] [**soil scientist (CPSS) certified by SSSA**] [**soil classifier (CPSC) certified by SSSA**] [**soil scientist (RPSS) registered by the National Society of Consulting Soil Scientists**] [**or**] [**state-certified, -licensed, or -registered soil scientist**] <**Insert requirement**> under the direction of the testing agency.

1. Number and Location of Samples: Minimum of [**three**] [**eight**] <**Insert number**> representative soil samples [**from varied locations**] [**where indicated on Drawings**] [**where directed by Architect**] <**Insert requirement**> for each soil to be used or amended for landscaping purposes.
2. Procedures and Depth of Samples: [**According to USDA-NRCS's "Field Book for Describing and Sampling Soils."**] [**As directed by Architect.**] <**Insert requirement.**>
3. Division of Samples: Split each sample into two, equal parts. Send half to the testing agency and half to Owner for its records.
4. Labeling: Label each sample with the date, location keyed to a site plan or other location system, visible soil condition, and sampling depth.

1.12 TESTING REQUIREMENTS

A. General: Perform tests on soil samples according to requirements in this article.

B. Physical Testing:

1. Soil Texture: Soil-particle, size-distribution analysis by[ **one of**] the following methods according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods":

a. Sieving Method: Report sand-gradation percentages for very coarse, coarse, medium, fine, and very fine sand; and fragment-gradation (gravel) percentages for fine, medium, and coarse fragments; according to USDA sand and fragment sizes.
b. Hydrometer Method: Report percentages of sand, silt, and clay.

2. Total Porosity: Calculate using particle density and bulk density according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
3. Water Retention: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
4. Saturated Hydraulic Conductivity: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods"; at 85% compaction according to ASTM D 698 (Standard Proctor).

C. Chemical Testing:

1. CEC: Analysis by sodium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."
2. Clay Mineralogy: Analysis and estimated percentage of expandable clay minerals using CEC by ammonium saturation at pH 7 according to SSSA's "Methods of Soil Analysis - Part 1- Physical and Mineralogical Methods."
3. Metals Hazardous to Human Health: Test for presence and quantities of RCRA metals including aluminum, arsenic, barium, copper, cadmium, chromium, cobalt, lead, lithium, and vanadium. If RCRA metals are present, include recommendations for corrective action.
4. Phytotoxicity: Test for plant-available concentrations of phytotoxic minerals including aluminum, arsenic, barium, cadmium, chlorides, chromium, cobalt, copper, lead, lithium, mercury, nickel, selenium, silver, sodium, strontium, tin, titanium, vanadium, and zinc.

D. Fertility Testing: Soil-fertility analysis according to standard laboratory protocol of [**SSSA NAPT NCR-13**] [**SSSA NAPT NEC-67**] [**SSSA NAPT SERA-6**] [**SSSA NAPT WERA-103**], including the following:

1. Percentage of organic matter.
2. CEC, calcium percent of CEC, and magnesium percent of CEC.
3. Soil reaction (acidity/alkalinity pH value).
4. Buffered acidity or alkalinity.
5. Nitrogen ppm.
6. Phosphorous ppm.
7. Potassium ppm.
8. Manganese ppm.
9. Manganese-availability ppm.
10. Zinc ppm.
11. Zinc availability ppm.
12. Copper ppm.
13. Sodium ppm[ **and sodium absorption ratio**].
14. Soluble-salts ppm.
15. Presence and quantities of problem materials including salts and metals cited in the Standard protocol. If such problem materials are present, provide additional recommendations for corrective action.
16. Other deleterious materials, including their characteristics and content of each.

E. Organic-Matter Content: Analysis using loss-by-ignition method according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."

F. Recommendations: Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated to produce satisfactory planting soil suitable for healthy, viable plants indicated. Include, at a minimum, recommendations for nitrogen, phosphorous, and potassium fertilization, and for micronutrients.

1. Fertilizers and Soil Amendment Rates: State recommendations in weight [**per 1000 sq. ft. (100 sq. m) for 6-inch (150-mm)depth of soil**] <**Insert requirement**>.
2. Soil Reaction: State the recommended liming rates for raising pH or sulfur for lowering pH according to the buffered acidity or buffered alkalinity in weight [**per 1000 sq. ft. (100 sq. m) for 6-inch (150-mm)depth of soil**] <**Insert requirement**>.

## 1.13 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance with state and Federal laws if applicable.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. 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.
3. Do not move or handle materials when they are wet or frozen.
4. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

# PART 2 - PRODUCTS

## 2.1 MATERIALS

A. <Double click to insert sustainable design text for regional materials.>

## 2.2 PLANTING SOILS SPECIFIED BY COMPOSITION

A. General: Soil amendments, fertilizers, and rates of application specified in this article are guidelines that may need revision based on testing laboratory's recommendations after preconstruction soil analyses are performed.

B. Planting-Soil Type <**Insert drawing designation**>: Existing, on-site surface soil, with the duff layer, if any, retained[**; and stockpiled on-site**]; modified to produce viable planting soil. Blend existing, on-site surface soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:

1. Ratio of Loose Compost to Soil: [**1:4**] [**1:3**] [**1:2**] <**Insert ratio**> by volume.
2. Ratio of Loose [**Sphagnum**] [**Muck**] Peat to Soil: <**Insert ratio**> by volume.
3. Ratio of Loose Wood Derivatives Soil: <**Insert ratio**> by volume.
4. Weight of Lime: <**Insert weight**> per [**1000 sq. ft. (100 sq. m)**] <**Insert area**> per [**6 inches (150 mm)**] <**Insert dimension**> of soil depth.
5. Weight of [**Sulfur**] [**Iron Sulfate**]: <**Insert weight**> per [**1000 sq. ft. (100 sq. m)**] <**Insert area**> per [**6 inches (150 mm)**] <**Insert dimension**> of soil depth.
6. Weight of Agricultural Gypsum: <**Insert weight**> per [**1000 sq. ft. (100 sq. m)**] <**Insert area**> per [**6 inches (150 mm)**] <**Insert dimension**> of soil depth.
7. Weight of Superphosphate: <**Insert weight**> per [**1000 sq. ft. (100 sq. m)**] <**Insert area**> per [**6 inches (150 mm)**] <**Insert dimension**> of soil depth.
8. Weight of Commercial Fertilizer: <**Insert weight**> per [**1000 sq. ft. (100 sq. m)**] <**Insert area**> per [**6 inches (150 mm)**] <**Insert dimension**> of soil depth.
9. Weight of Slow-Release Fertilizer: <**Insert weight**> per [**1000 sq. ft. (100 sq. m)**] <**Insert area**> per [**6 inches (150 mm)**] <**Insert dimension**> of soil depth.

C. Planting-Soil Type <**Insert drawing designation**>: Imported, naturally formed soil from off-site sources and consisting of [**sandy loam**] [**loam**] [**silt loam**] [**loamy sand**] [**or**] [**sand**] soil <**Insert soil texture**> according to USDA textures; and modified to produce viable planting soil.

1. Sources: Take imported, unamended soil from sources that are naturally well-drained sites where topsoil occurs at least 4 inches (100 mm) deep, not from [**agricultural land,** ]bogs, or marshes; and that do not contain undesirable organisms; disease-causing plant pathogens; or obnoxious weeds and invasive plants including, but not limited to, quackgrass, Johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel, and bromegrass.
2. Additional Properties of Imported Soil before Amending: Soil reaction of [**pH 6 to 7**] <**Insert range**> and minimum of [**2**] [**4**] [**6**] <**Insert number**> percent organic-matter content, friable, and with sufficient structure to give good tilth and aeration.
3. Unacceptable Properties: Clean soil of the following:

    a. Unacceptable Materials: Concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.
    b. Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of [**8**] <**Insert number**> percent by dry weight of the imported soil.
    c. Large Materials: Stones, clods, roots, clay lumps, and pockets of coarse sand exceeding [**2 inches (50 mm)**] [**3 inches (75 mm)**] <**Insert dimension**> in any dimension.

4. Amended Soil Composition: Blend imported, unamended soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:

    a. Ratio of Loose Compost to Soil: [**1:4**] [**1:3**] [**1:2**] <**Insert ratio**> by volume.
    b. Ratio of Loose [**Sphagnum**] [**Muck**] Peat to Soil: <**Insert ratio**> by volume.
    c. Ratio of Loose Wood Derivatives to Soil: <**Insert ratio**> by volume.
    d. Weight of Lime: <**Insert weight**> per [**1000 sq. ft. (100 sq. m)**] <**Insert area**> per [**6 inches (150 mm)**] <**Insert dimension**> of soil depth.

e. Weight of [**Sulfur**] [**Iron Sulfate**]: <**Insert weight**> per [**1000 sq. ft. (100 sq. m)**] <**Insert area**> per [**6 inches (150 mm)**] <**Insert dimension**> of soil depth.
f. Weight of Agricultural Gypsum: <**Insert weight**> per [**1000 sq. ft. (100 sq. m)**] <**Insert area**> per [**6 inches (150 mm)**] <**Insert dimension**> of soil depth.
g. Weight of Superphosphate: <**Insert weight**> per [**1000 sq. ft. (100 sq. m)**] <**Insert area**> per [**6 inches (150 mm)**] <**Insert dimension**> of soil depth.
h. Weight of Commercial Fertilizer: <**Insert weight**> per [**1000 sq. ft. (100 sq. m)**] <**Insert area**> per [**6 inches (150 mm)**] <**Insert dimension**> of soil depth.
i. Weight of Slow-Release Fertilizer: <**Insert weight**> per [**1000 sq. ft. (100 sq. m)**] <**Insert area**> per [**6 inches (150 mm)**] <**Insert dimension**> of soil depth.

D. Planting-Soil Type <**Insert drawing designation**>: Manufactured soil consisting of manufacturer's basic [**topsoil,**] [**sandy loam according to USDA textures,**] <**Insert soil texture or manufacturer's base-soil designation**> blended in a manufacturing facility with sand, stabilized organic soil amendments, and other materials to produce viable planting soil.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Additional Properties of Manufacturer's Basic Soil before Amending: Soil reaction of [**pH 6 to 7**] <**Insert range**> and minimum of [**2**] [**4**] [**6**] <**Insert number**> percent organic-matter content, friable, and with sufficient structure to give good tilth and aeration.
3. Unacceptable Properties: Manufactured soil shall not contain the following:

a. Unacceptable Materials: Concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.
b. Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of [**5**] <**Insert number**> percent by dry weight of the manufactured soil.
c. Large Materials: Stones, clods, roots, clay lumps, and pockets of coarse sand exceeding [**1-1/2 inches (38 mm)**] [**2 inches (50 mm)**] <**Insert dimension**> in any dimension.

4. Blend manufacturer's basic soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:

a. Ratio of Loose Compost to Soil: [**1:4**] [**1:3**] [**1:2**] <**Insert ratio**> by volume.
b. Ratio of Loose [**Sphagnum**] [**Muck**] Peat to Soil: <**Insert ratio**> by volume.
c. Ratio of Loose Wood Derivatives Soil: <**Insert ratio**> by volume.
d. Volume of Sand: <**Insert volume**> per [**cu. yd. (cu. m)**] <**Insert value**>.
e. Volume of Perlite: <**Insert volume**> per [**cu. yd. (cu. m)**] <**Insert value**>.
f. Weight of Lime: <**Insert weight**> per [**cu. yd. (cu. m)**] <**Insert value**>.
g. Weight of [**Sulfur**] [**Iron Sulfate**]: <**Insert weight**> per [**cu. yd. (cu. m)**] <**Insert value**>.
h. Weight of Agricultural Gypsum: <**Insert weight**> per [**cu. yd. (cu. m)**] <**Insert value**>.
i. Weight of Superphosphate: <**Insert weight**> per [**cu. yd. (cu. m)**] <**Insert value**>.
j. Weight of Commercial Fertilizer: <**Insert weight**> per [**cu. yd. (cu. m)**] <**Insert value**>.

k. Weight of Slow-Release Fertilizer: <**Insert weight**> per [**cu. yd. (cu. m)**] <**Insert value**>.

## 2.3 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:

1. Class: T, with a minimum of 99 percent passing through a No. 8 (2.36-mm) sieve and a minimum of 75 percent passing through a No. 60 (0.25-mm) sieve.
2. Class: O, with a minimum of 95 percent passing through a No. 8 (2.36-mm) sieve and a minimum of 55 percent passing through a No. 60 (0.25-mm) sieve.
3. Form: Provide lime in form of ground [**dolomitic limestone**] [**calcitic limestone**] [**mollusk shells**] <**Insert material**>.

B. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent elemental sulfur, with a minimum of 99 percent passing through a No. 6 (3.35-mm) sieve and a maximum of 10 percent passing through a No. 40 (0.425-mm) sieve.

C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.

D. Perlite: Horticultural perlite, soil amendment grade.

E. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through a No. 50 (0.30-mm) sieve.

F. Sand: Clean, washed, natural or manufactured, free of toxic materials, and according to [**ASTM C 33/C 33M**] <**Insert requirement**>.

## 2.4 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter produced by composting feedstock, and bearing USCC's "Seal of Testing Assurance," and as follows:

1. Feedstock: [**Limited to leaves**] [**May include sewage sludge**] [**May include animal waste**] <**Insert requirement**>.
2. Reaction: [**pH of 5.5 to 8**] <**Insert range**>.
3. Soluble-Salt Concentration: Less than [**4**] <**Insert value**> dS/m.
4. Moisture Content: [**35 to 55**] <**Insert number range**> percent by weight.
5. Organic-Matter Content: [**30 to 40**] [**50 to 60**] <**Insert number range**> percent of dry weight.
6. Particle Size: Minimum of 98 percent passing through a [**4-inch (100-mm)**] [**2-inch (50-mm)**] [**1-inch (25-mm)**] [**1/2-inch (13-mm)**] sieve.

B. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture with 100 percent passing through a [**1/2-inch (13-mm)**] <**Insert dimension**> sieve, a pH of 3.4 to 4.8, and a soluble-salt content measured by electrical conductivity of [**maximum 5**] <**Insert value or range**> dS/m.

C. Muck Peat: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture with 100 percent passing through a [**1/2-inch (13-mm)**] <**Insert dimension**> sieve, a pH of 6 to 7.5, a soluble-salt content measured by electrical conductivity of [**maximum 5**] <**Insert value or range**> dS/m, having a water-absorbing capacity of 1100 to 2000 percent, and containing no sand.

D. Wood Derivatives: Shredded and composted, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.

1. Partially Decomposed Wood Derivatives: In lieu of shredded and composted wood derivatives, mix shredded and partially decomposed wood derivatives with ammonium nitrate at a minimum rate of [**0.15 lb/cu. ft. (2.4 kg/cu. m)**] <**Insert value**> of loose sawdust or ground bark, or with ammonium sulfate at a minimum rate of [**0.25 lb/cu. ft. (4 kg/cu. m)**] <**Insert value**> of loose sawdust or ground bark.

E. 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.

## 2.5 FERTILIZERS

A. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of [**20**] [**33**] [**50**] percent available phosphoric acid.

B. 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:

1. Composition: [**1 lb/1000 sq. ft. (0.5 kg/100 sq. m)**] <**Insert value**> of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.

C. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.

D. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.

PART 3 - EXECUTION

3.1 GENERAL

A. Place planting soil and fertilizers according to requirements in other Specification Sections.

B. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in planting soil.

C. Proceed with placement only after unsatisfactory conditions have been corrected.

3.2 PREPARATION OF UNAMENDED, ON-SITE SOIL BEFORE AMENDING

A. Excavation: Excavate soil from designated area(s) to a depth of [**6 inches (150 mm)**] <**Insert dimension**> and stockpile until amended.

B. Unacceptable Materials: Clean soil of concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.

C. Unsuitable Materials: Clean soil to contain a maximum of [**8**] <**Insert number**> percent by dry weight of stones, roots, plants, sod, clay lumps, and pockets of coarse sand.

D. Screening: Pass unamended soil through a [**2-inch (50-mm)**] [**3-inch (75-mm)**] <**Insert dimension**> sieve to remove large materials.

3.3 PLACING AND MIXING PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply and mix unamended soil with amendments on-site to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Subgrade Preparation: Till subgrade to a minimum depth of [**4 inches (100 mm)**] [**6 inches (150 mm)**] [**8 inches (200 mm)**] [**12 inches (300 mm)**] [**18 inches (450 mm)**] <**Insert dimension**>. Remove stones larger than [**1-1/2 inches (38 mm)**] [**2 inches (50 mm)**] [**3 inches (75 mm)**] <**Insert dimension**> in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Apply, add soil amendments, and mix approximately half the thickness of unamended soil over prepared, loosened subgrade according to "Mixing" Paragraph below. Mix thoroughly into top [**2 inches (50 mm)**] [**4 inches (100 mm)**] of subgrade. Spread remainder of planting soil.

C. Mixing: Spread unamended soil to total depth [**of 4 inches (100 mm)**] [**of 6 inches (150 mm)**] [**of 8 inches (200 mm)**] [**of 12 inches (300 mm)**] [**indicated on Drawings**] <**Insert dimension**>, but not less than required to meet finish grades after mixing with amendments and natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.

1. Amendments: Apply soil amendments[**, except compost,**] and fertilizer, if required, evenly on surface, and thoroughly blend them with unamended soil to produce planting soil.

    a. Mix [**lime**] [**and**] [**sulfur**] with dry soil before mixing fertilizer.
    b. Mix fertilizer with planting soil no more than seven days before planting.

2. Lifts: Apply and mix unamended soil and amendments in lifts not exceeding [**8 inches (200 mm)**] [**12 inches (300 mm)**] <**Insert dimension**> in loose depth for material compacted by compaction equipment, and not more than [**4 inches (100 mm)**] [**6 inches (150 mm)**] in loose depth for material compacted by hand-operated tampers.

D. Compaction: Compact each blended lift of planting soil to [**75 to 82**] <**Insert number range**> percent of maximum Standard Proctor density according to ASTM D 698 and tested in-place[ **except where a different compaction value is indicated on Drawings**].

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

## 3.4 PLACING MANUFACTURED PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply manufactured soil on-site in its final, blended condition. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Subgrade Preparation: Till subgrade to a minimum depth of [**4 inches (100 mm)**] [**6 inches (150 mm)**] [**8 inches (200 mm)**] [**12 inches (300 mm)**] [**18 inches (450 mm)**] <**Insert dimension**>. Remove stones larger than [**1-1/2 inches (38 mm)**] [**2 inches (50 mm)**] [**3 inches (75 mm)**] <**Insert dimension**> in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Apply approximately half the thickness of planting soil over prepared, loosened subgrade. Mix thoroughly into top [**2 inches (50 mm)**] [**4 inches (100 mm)**] of subgrade. Spread remainder of planting soil.

C. Application: Spread planting soil to total depth [**of 4 inches (100 mm)**] [**of 6 inches (150 mm)**] [**of 8 inches (200 mm)**] [**of 12 inches (300 mm)**] [**indicated on Drawings**] <**Insert dimension**>, but not less than required to meet finish grades after natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.

1. Lifts: Apply planting soil in lifts not exceeding [**8 inches (200 mm)**] [**12 inches (300 mm)**] <**Insert dimension**> in loose depth for material compacted by compaction equipment, and not more than [**4 inches (100 mm)**] [**6 inches (150 mm)**] in loose depth for material compacted by hand-operated tampers.

D. Compaction: Compact each lift of planting soil to [**75 to 82**] <**Insert number range**> percent of maximum Standard Proctor density according to ASTM D 698[ **except where a different compaction value is indicated on Drawings**].

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

## 3.5 BLENDING PLANTING SOIL IN PLACE

A. General: Mix amendments with in-place, unamended soil to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Preparation: Till unamended, existing soil in planting areas to a minimum depth of [**of 4 inches (100 mm)**] [**of 6 inches (150 mm)**] [**of 8 inches (200 mm)**] [**of 12 inches (300 mm)**] [**of 18 inches (450 mm)**] [**indicated on Drawings**] <**Insert dimension**>. Remove stones larger than [**1-1/2 inches (38 mm)**] [**2 inches (50 mm)**] [**3 inches (75 mm)**] <**Insert dimension**> in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

C. Mixing: Apply soil amendments[**, except compost,**] and fertilizer, if required, evenly on surface, and thoroughly blend them into full depth of unamended, in-place soil to produce planting soil.

1. Mix [**lime**] [**and**] [**sulfur**] with dry soil before mixing fertilizer.
2. Mix fertilizer with planting soil no more than seven days before planting.

D. Compaction: Compact blended planting soil to [**75 to 82**] <**Insert number range**> percent of maximum Standard Proctor density according to ASTM D 698[ **except where a different compaction value is indicated on Drawings**].

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

## 3.6 APPLYING COMPOST TO SURFACE OF PLANTING SOIL

A. Application: Apply [**compost component of planting-soil mix**] [**4 inches (100 mm) of compost**] [**6 inches (150 mm) of compost**] <**Insert depth**> to surface of in-place planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Finish Grading: Grade surface to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

## 3.7 LAYERED SOIL ASSEMBLIES

A. Layered Soil Assembly <**Insert designation**>:

1. [**Top Layer**] <**Insert layer designation**>: Planting-soil type <**Insert drawing designation**>.
2. <**Insert layer designation**>: Planting-soil type <**Insert drawing designation**>.

## 3.8 FIELD QUALITY CONTROL

A. Testing Agency: [**Owner will engage**] [**Engage**] a qualified testing agency to perform tests and inspections.

B. Perform the following tests[ **and inspections**]:

1. Compaction: Test planting-soil compaction after placing each lift and at completion using a densitometer or soil-compaction meter calibrated to a reference test value based on laboratory testing according to ASTM D 698. Space tests at no less than one for each [**1000 sq. ft. (100 sq. m)**] [**2000 sq. ft. (200 sq. m)**] <**Insert dimension**> of in-place soil or part thereof.
2. <**Insert name of test**>: <**Insert requirement**>.
3. <**Insert name of inspection**>: <**Insert requirement**>.

C. Soil will be considered defective if it does not pass tests[ **and inspections**].

D. Prepare test[ **and inspection**] reports.

E. Label each sample and test report with the date, location keyed to a site plan or other location system, visible conditions when and where sample was taken, and sampling depth.

## 3.9 PROTECTION

A. Protection Zone: Identify protection zones according to Section 015639 "Temporary Tree and Plant Protection."

B. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Vehicle traffic.
4. Foot traffic.
5. Erection of sheds or structures.
6. Impoundment of water.
7. Excavation or other digging unless otherwise indicated.

C. If planting soil or subgrade is overcompacted, disturbed, or contaminated by foreign or deleterious materials or liquids, remove the planting soil and contamination; restore the subgrade as directed by Architect and replace contaminated planting soil with new planting soil.

## 3.10 CLEANING

A. Protect areas adjacent to planting-soil preparation and placement areas from contamination. Keep adjacent paving and construction clean and work area in an orderly condition.

B. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.

1. Dispose of excess subsoil and unsuitable materials on-site where directed by Owner.

END OF SECTION 32 91 13

# SECTION 32 92 00 - TURF AND GRASSES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. Section Includes:

1. Seeding.
2. Hydroseeding.
3. Sodding.
4. Plugging.
5. Sprigging.
6. Meadow grasses and wildflowers.
7. Turf renovation.
8. Erosion-control material(s).
9. Grass paving.

B. Related Requirements:

1. Section 329300 "Plants" for trees, shrubs, ground covers, and other plants as well as border edgings and mow strips.
2. Section 334600 "Subdrainage" for below-grade drainage of landscaped areas.

### 1.3 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

D. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See [**Section 329113 "Soil Preparation"**] [**Section 329115 "Soil Preparation (Performance Specification)"**] and drawing designations for planting soils.

E. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

## 1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at [**Project site**] <**Insert location**>.

## 1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For landscape Installer.

B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture, stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

1. Certification of each seed mixture for [**turfgrass sod**] [**plugs**]. Include identification of source and name and telephone number of supplier.

C. Product Certificates: For fertilizers, from manufacturer.

D. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

## 1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of turf[ **and meadows**] during a calendar year. Submit before expiration of required maintenance periods.

## 1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful turf[ **and meadow**] establishment.

1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
2. Experience: [**Three**] [**Five**] <**Insert number**> years' experience in turf installation in addition to requirements in Section 014000 "Quality Requirements."
3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
4. Personnel Certifications: Installer's [**field supervisor**] [**personnel assigned to the Work**] shall have certification in [**one of**] [**all of**] the following categories from the Professional Landcare Network:

a. Landscape Industry Certified Technician - Exterior.
b. Landscape Industry Certified Lawncare Manager.

c. Landscape Industry Certified Lawncare Technician.

5. Pesticide Applicator: State licensed, commercial.

## 1.8 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.

B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" sections in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod within 24 hours of harvesting and in time for planting promptly. Protect sod from breakage and drying.

C. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. 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.
3. Accompany each delivery of bulk materials with appropriate certificates.

## 1.9 FIELD CONDITIONS

A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of [**planting completion**] [**Substantial Completion**] <**Insert starting time**>.

1. Spring Planting: <**Insert dates**>.
2. Fall Planting: <**Insert dates**>.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

# PART 2 - PRODUCTS

## 2.1 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Rules for Testing Seeds" for purity and germination tolerances.

B. Seed Species:

1. Quality: State-certified seed of grass species as listed below for solar exposure.

2. Quality: Seed of grass species as listed below for solar exposure, with not less than [**85**] <**Insert number**> percent germination, not less than [**95**] <**Insert number**> percent pure seed, and not more than [**0.5**] <**Insert number**> percent weed seed:
3. Full Sun: Bermudagrass (Cynodon dactylon).
4. Full Sun: Kentucky bluegrass (Poa pratensis), a minimum of three cultivars.
5. 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).

6. 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).

C. Grass-Seed Mix: Proprietary seed mix as follows:

1. Products: Subject to compliance with requirements, [**provide the following**] [**provide one of the following**] [**available products that may be incorporated into the Work include, but are not limited to, the following**]:

    a. <**Insert manufacturer's name; product name or designation**>.

## 2.2 TURFGRASS SOD

A. Turfgrass Sod: [**Certified**] [**Approved**] [**Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects**], complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture that is strongly rooted and capable of vigorous growth and development when planted.

B. Turfgrass Species: [**Bermudagrass (Cynodon dactylon)**] [**Carpetgrass (Axonopus affinis)**] [**Centipedegrass (Eremochloa ophiuroides)**] [**St. Augustinegrass (Stenotaphrum secundatum)**] [**Zoysiagrass (Zoysia japonica)**] [**Zoysiagrass (Zoysia matrella)**] <**Insert species**>.

C. Turfgrass Species: Sod of grass species as follows, with not less than [**85**] <**Insert number**> percent germination, not less than [**95**] <**Insert number**> percent pure seed, and not more than [**0.5**] <**Insert number**> percent weed seed:

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).

## 2.3 PLUGS

A. Plugs: Turfgrass sod, [**Certified**] [**Approved**] [**Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects**], complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture that is 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:

1. Turfgrass Species: [**Bermudagrass (Cynodon dactylon)**] [**Carpetgrass (Axonopus affinis)**] [**Centipedegrass (Eremochloa ophiuroides)**] [**St. Augustinegrass (Stenotaphrum secundatum)**] [**Zoysiagrass (Zoysia japonica)**] [**Zoysiagrass (Zoysia matrella)**] <**Insert species**>.
2. Plug Size: [**2 inches (50 mm)**] [**3 inches (75 mm)**] [**4 inches (100 mm)**] <**Insert dimension**>.

## 2.4 SPRIGS

A. 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:

1. Turfgrass Species: [**Bermudagrass (Cynodon dactylon)**] [**Carpetgrass (Axonopus affinis)**] [**Centipedegrass (Eremochloa ophiuroides)**] [**St. Augustinegrass (Stenotaphrum secundatum)**] [**Zoysiagrass (Zoysia japonica)**] [**Zoysiagrass (Zoysia matrella)**] <**Insert species**>.
2. Turfgrass Species: Creeping bentgrass (Agrostis palustris).

## 2.5 MEADOW GRASSES AND WILDFLOWERS

A. Wildflower Seed: Fresh, clean, and dry new seed, of mixed species as follows:

1. <**Insert mix of wildflower species**>.

B. Native-Grass Seed: Fresh, clean, and dry new seed, of mixed species as follows:

1. <**Insert mix of native-grass species**>.

C. Wildflower and Native-Grass Seed: Fresh, clean, and dry new seed, of mixed species as follows:

1. <**Insert mix of wildflower and native-grass species**>.

D. Seed Carrier: Inert material, sharp clean sand or perlite.

## 2.6 FERTILIZERS

A. 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:

1. Composition: [**1 lb/1000 sq. ft. (0.45 kg/92.9 sq. m)**] <**Insert value**> of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

## 2.7 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

B. 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.

C. 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, and containing no sand.

D. 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**] <**Insert range or value**> decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

1. Organic Matter Content: [**50 to 60**] <**Insert number range**> percent of dry weight.
2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

E. 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.

F. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.

G. Asphalt Emulsion: ASTM D 977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

## 2.8 PESTICIDES

A. General: Pesticide, registered and approved by the 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.

B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

## 2.9 EROSION-CONTROL MATERIALS

A. 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.

B. 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.

C. Erosion-Control Mats: Cellular, nonbiodegradable slope-stabilization mats designed to isolate and contain small areas of soil over steeply sloped surface, of [**3-inch (75-mm)**] [**4-inch (100-mm)**] [**6-inch (150-mm)**] <**Insert dimension**> nominal mat thickness. Include manufacturer's recommended anchorage system for slope conditions.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

## 2.10 GRASS-PAVING MATERIALS

A. Grass Paving: Cellular, nonbiodegradable 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)**] [**1-3/4-inch (45-mm)**] [**2-inch (50-mm)**] [**manufacturer's standard**] <**Insert dimension**> nominal mat thickness. Include manufacturer's recommended anchorage system for slope conditions.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Base Course: Sound crushed stone or gravel complying with [**ASTM D 448 for Size No. 8**] [**Section 312000 "Earth Moving" for base-course material**] <**Insert requirements**>.

C. Sand: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33/C 33M for fine aggregate.

D. Proprietary Growing Mix: As submitted and acceptable to Architect.

E. Sandy Loam Soil Mix: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33/C 33M for fine aggregate blended with planting soil <**Insert drawing designation**>. Use blend consisting of [**1/2 sand and 1/2 planting soil**] [**2/3 sand and 1/3 planting soil**] <**Insert proportions**>.

F. Soil for Paving Fill: Planting soil <**Insert drawing designation**>.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting installation and performance of the Work.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
3. Uniformly moisten excessively dry soil that is not workable or which is dusty.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

### 3.2 PREPARATION

A. Protect structures; utilities; sidewalks; pavements; and other facilities, trees, shrubs, and plantings from damage caused by planting operations.

1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
2. Protect grade stakes set by others until directed to remove them.

B. 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.

### 3.3 TURF AREA PREPARATION

A. General: Prepare planting area for soil placement and mix planting soil according to [**Section 329113 "Soil Preparation."**] [**Section 329115 "Soil Preparation (Performance Specification)."**]

B. Placing Planting Soil: [**Place and mix planting soil in place over exposed subgrade**] [**Place manufactured planting soil over exposed subgrade**] [**Blend planting soil in place**] <**Insert requirement**>.

1. Reduce elevation of planting soil to allow for soil thickness of sod.

C. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

D. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

## 3.4 PREPARATION FOR EROSION-CONTROL MATERIALS

A. Prepare area as specified in "Turf Area Preparation" Article.

B. 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.

C. Fill cells of erosion-control mat with planting soil and compact before planting.

D. 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.

E. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

## 3.5 PREPARATION FOR GRASS-PAVING MATERIALS

A. 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.

B. Install [**base course**] [**and**] [**sand course**] and [**sandy loam soil mix**] [**proprietary growing mix**] [**soil for paving fill**] as recommended by paving-material manufacturer for site conditions and according to details indicated on Drawings. Compact according to paving-material manufacturer's written instructions.

C. Install paving mat and fasten according to paving-material manufacturer's written instructions.

D. Before planting, fill cells of paving mat with [**planting soil**] [**sandy loam soil mix**] [**proprietary growing mix**] [**sand half full**] and compact according to manufacturer's written instructions.

E. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

## 3.6 SEEDING

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph (8 km/h).

1. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
2. Do not use wet seed or seed that is moldy or otherwise damaged.
3. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.

B. Sow seed at a total rate of [**2 lb/1000 sq. ft. (0.9 kg/92.9 sq. m)**] [**3 to 4 lb/1000 sq. ft. (1.4 to 1.8 kg/92.9 sq. m)**] [**5 to 8 lb/1000 sq. ft. (2.3 to 3.6 kg/92.9 sq. m)**] <**Insert values**>.

C. Rake seed lightly into top 1/8 inch (3 mm) of soil, roll lightly, and water with fine spray.

D. 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.

E. Protect seeded areas with erosion-control mats where indicated on Drawings; install and anchor according to manufacturer's written instructions.

F. 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)**] <**Insert values**> to form a continuous blanket [**1-1/2 inches (38 mm)**] <**Insert dimension**> in loose thickness over seeded areas. Spread by hand, blower, or other suitable equipment.

1. Anchor straw mulch by crimping into soil with suitable mechanical equipment.
2. 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)**] <**Insert values**>. Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.

G. Protect seeded areas from hot, dry weather or drying winds by applying [**compost mulch**] [**peat mulch**] [**planting soil**] within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of [**3/16 inch (4.8 mm)**] <**Insert dimension**>, and roll surface smooth.

## 3.7 HYDROSEEDING

A. Hydroseeding: Mix specified seed, [**commercial fertilizer**] [**slow-release fertilizer**] <**Insert type**>, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.

1. Mix slurry with [**nonasphaltic**] [**asphalt-emulsion**] [**fiber-mulch manufacturer's recommended**] tackifier.
2. Spray-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)**] <**Insert values**> dry weight, and seed component is deposited at not less than the specified seed-sowing rate.

3. Spray-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)**] <**Insert values**> 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)**] <**Insert values**>.

## 3.8 SODDING

A. Lay sod within 24 hours of harvesting[ **unless a suitable preservation method is accepted by Architect prior to delivery time**]. Do not lay sod if dormant or if ground is frozen or muddy.

B. 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 soil or sod during installation. Tamp and roll lightly to ensure contact with soil, 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.

1. Lay sod across slopes exceeding 1:3.
2. Anchor sod on slopes exceeding 1:6 with wood pegs[ **or steel staples**] spaced as recommended by sod manufacturer but not less than two anchors per sod strip to prevent slippage.

C. 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.

## 3.9 PLUGGING

A. Plant plugs in holes or furrows, spaced [**12 inches (300 mm)**] [**18 inches (450 mm)**] <**Insert dimension**> apart in [**both directions**] [**triangular pattern**]. On slopes, contour furrows to near level.

## 3.10 SPRIGGING

A. Plant freshly shredded sod sprigs in furrows [**1 to 1-1/2 inches (25 to 38 mm)**] [**1-1/2 to 2 inches (38 to 50 mm)**] [**2-1/2 to 3 inches (64 to 75 mm)**] deep. Place individual sprigs with roots and portions of stem in moistened soil, [**6 inches (150 mm)**] [**12 inches (300 mm)**] <**Insert dimension**> apart in rows [**10 inches (250 mm)**] [**18 inches (450 mm)**] <**Insert dimension**> apart, and fill furrows without covering growing tips. Lightly roll and firm soil around sprigs after planting.

B. Broadcast sprigs uniformly over prepared surface at a rate of [**10 cu. ft./1000 sq. ft. (0.28 cu. m/92.9 sq. m)**] <**Insert values**> and mechanically force sprigs into lightly moistened soil.

1. Spread a 1/4-inch- (6-mm-) thick layer of [**compost mulch**] [**peat mulch**] [**planting soil**] on sprigs.

2. Lightly roll and firm soil around sprigs after planting.
3. Water sprigs immediately after planting and keep moist by frequent watering until well rooted.

## 3.11 TURF RENOVATION

A. Renovate existing turf where indicated.

B. Renovate turf damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.

1. Reestablish turf where settlement or washouts occur or where minor regrading is required.
2. Install new planting soil as required.

C. Remove sod and vegetation from diseased or unsatisfactory turf areas; do not bury in soil.

D. 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.

E. Mow, dethatch, core aerate, and rake existing turf.

F. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergence herbicides.

G. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.

H. Till stripped, bare, and compacted areas thoroughly to a soil depth of 6 inches (150 mm).

I. Apply[ **soil amendments and**] initial fertilizer 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.

1. Soil Amendment(s): <**Insert required soil amendment(s)**> according to requirements of [**Section 329113 "Soil Preparation."**] [**Section 329115 "Soil Preparation (Performance Specification)."**] Apply <**Insert soil amendment**> at the rate of <**Insert application rate**>.
2. Initial Fertilizer: [**Commercial fertilizer**] [**Slow-release fertilizer**] <**Insert type**> applied according to manufacturer's recommendations.

J. Apply [**seed and protect with straw mulch**] [**sod**] [**plugs**] [**sprigs**] as required for new turf.

K. Water newly planted areas and keep moist until new turf is established.

## 3.12 TURF MAINTENANCE

A. General: 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.

1. 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.
2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
3. 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.

B. 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).

1. 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.
2. Water turf with fine spray at a minimum rate of 1 inch (25 mm) per week unless rainfall precipitation is adequate.

C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than one-third of grass height. Remove no more than one-third 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:

1. Mow [**bentgrass**] <**Insert grass species**> to a height of 1/2 inch (13 mm) or less.
2. Mow [**bermudagrass**] <**Insert grass species**> to a height of 1/2 to 1 inch (13 to 25 mm).
3. Mow [**carpetgrass**] [**centipedegrass**] [**perennial ryegrass**] [**zoysiagrass**] <**Insert grass species**> to a height of 1 to 2 inches (25 to 50 mm).
4. Mow [**Kentucky bluegrass**] [**buffalograss**] [**annual ryegrass**] [**chewings red fescue**] <**Insert grass species**> to a height of 1-1/2 to 2 inches (38 to 50 mm).
5. Mow [**bahiagrass**] [**turf-type tall fescue**] [**St. Augustinegrass**] <**Insert grass species**> to a height of 2 to 3 inches (50 to 75 mm).

D. Turf Postfertilization: Apply [**commercial fertilizer**] [**slow-release fertilizer**] <**Insert type**> after initial mowing and when grass is dry.

1. Use fertilizer that provides actual nitrogen of at least [**1 lb/1000 sq. ft. (0.45 kg/92.9 sq. m)**] <**Insert value**> to turf area.

## 3.13 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Architect:

1. 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)**] <**Insert coverage**>.
2. 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.
3. 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.
4. 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.

B. Use specified materials to reestablish turf that does not comply with requirements, and continue maintenance until turf is satisfactory.

## 3.14 MEADOW

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph (8 km/h).

1. Before sowing, mix seed with seed carrier at a ratio of not less than [**two**] [**three**] [**four**] <**Insert number**> parts seed carrier to one part seed.
2. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
3. Do not use wet seed or seed that is moldy or otherwise damaged.

B. Sow seed at a total rate of [**4 oz./1000 sq. ft. (113 g/92.9 sq. m)**] [**5 oz./1000 sq. ft. (142 g/92.9 sq. m)**] [**6 oz./1000 sq. ft. (170 g/92.9 sq. m)**] <**Insert values**>.

C. Brush seed into top 1/16 inch (1.6 mm) of soil, roll lightly, and water with fine spray.

D. 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.

E. Water newly planted areas and keep moist until meadow is established.

## 3.15 MEADOW MAINTENANCE

A. 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.

1. 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.

2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
3. 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.

B. Watering: Install and maintain temporary piping, hoses, and meadow-watering equipment to convey water from sources and to keep meadow uniformly moist.

1. 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.
2. Water meadow with fine spray at a minimum rate of 1/2 inch (13 mm) per week for [**four**] [**six**] [**eight**] weeks after planting unless rainfall precipitation is adequate.

## 3.16 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents according to requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

## 3.17 CLEANUP AND PROTECTION

A. 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.

B. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

C. 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.

D. Remove nondegradable erosion-control measures after grass establishment period.

## 3.18 MAINTENANCE SERVICE

A. Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Turf Maintenance" Article. Begin maintenance immediately after each area is planted and continue until acceptable turf is established, but for not less than the following periods:

1. Seeded Turf: [**60**] <**Insert number**> days from date of [**planting completion**] [**Substantial Completion**] <**Insert starting time**>.

a. 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.

2. Sodded Turf: [**30**] <**Insert number**> days from date of [**planting completion**] [**Substantial Completion**] <**Insert starting time**>.
3. Plugged Turf: [**30**] <**Insert number**> days from date of [**planting completion**] [**Substantial Completion**] <**Insert starting time**>.
4. Sprigged Turf: [**30**] <**Insert number**> days from date of [**planting completion**] [**Substantial Completion**] <**Insert starting time**>.

B. Meadow Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Meadow Maintenance" Article. Begin maintenance immediately after each area is planted and continue until acceptable meadow is established, but for not less than maintenance period below.

1. Maintenance Period: [**40**] <**Insert number**> days from date of [**planting completion**] [**Substantial Completion**] <**Insert starting time**>.

END OF SECTION 32 92 00

# SECTION 32 93 00 - PLANTS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. Section Includes:

1. Plants.
2. Tree stabilization.
3. Tree-watering devices.
4. Landscape edgings.
5. Tree grates.

B. Related Requirements:

1. Section 015639 "Temporary Tree and Plant Protection" for protecting, trimming, pruning, repairing, and replacing existing trees to remain that interfere with, or are affected by, execution of the Work.
2. Section 129200 "Interior Planters and Artificial Plants" for planters for live and artificial interior plants.
3. Section 329200 "Turf and Grasses" for turf (lawn) and meadow planting, hydroseeding, and erosion-control materials.
4. Section 329600 "Transplanting" for transplanting non-nursery-grown trees.

### 1.3 ALLOWANCES

A. Allowances for plants are specified in Section 012100 "Allowances."

1. Perform planting work under quantity allowances and only as authorized. Authorized work includes [**work required by Drawings and the Specifications and**] [**only**] work authorized in writing by Architect.
2. Notify Architect [**weekly**] <**Insert time interval**> of extent of work performed that is attributable to quantity allowances.
3. Perform work that exceeds quantity allowances only as authorized by Change Orders.

B. Furnish trees as part of tree allowance.

C. Furnish <**Insert plant variety**> as part of <**Insert name of allowance**>.

1.4 UNIT PRICES

A. Work of this Section is affected by unit prices specified in Section 012200 "Unit Prices."

B. Unit prices apply to authorized work covered by quantity allowances.

C. Unit prices apply to additions to and deletions from the Work as authorized by Change Orders.

1.5 DEFINITIONS

A. Backfill: The earth used to replace or the act of replacing earth in an excavation.

B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with a ball size not less than [**sizes indicated**] [**diameter and depth recommended by ANSI Z60.1 for type and size of plant required**]; 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.

C. 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**] [**diameter and depth recommended by ANSI Z60.1 for type and size of plant required**].

D. 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 the minimum root spread according to ANSI Z60.1 for type and size of plant required.

E. 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.

F. 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.

G. Finish Grade: Elevation of finished surface of planting soil.

H. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant. Some sources classify herbicides separately from pesticides.

I. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

J. Planting Area: Areas to be planted.

K. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See [**Section 329113 "Soil Preparation"**] [**Section 329115 "Soil Preparation (Performance Specification)"**] for drawing designations for planting soils.

L. 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.

M. 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.

N. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.

O. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

## 1.6 COORDINATION

A. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.

1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

## 1.7 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at [**Project site**] <**Insert location**>.

## 1.8 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Plant Materials: Include quantities, sizes, quality, and sources for plant materials.
2. Plant Photographs: Include color photographs in [**digital**] [**3- by 5-inch (76- by 127-mm) print**] format of each required species and size of plant material as it will be furnished to Project. Take photographs from an angle depicting true size and condition of the typical plant to be furnished. Include a scale rod or other measuring device in each photograph. For species where more than [**20**] <**Insert number**> plants are required, include a minimum of [**three**] <**Insert number**> photographs showing the average plant, the best quality plant, and the worst quality plant to be furnished. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.

B. Samples for Verification: For each of the following:

1. Trees and Shrubs: [**Three**] <**Insert number**> Samples of each variety and size[ **delivered to site for review**]. Maintain approved Samples on-site as a standard for comparison.

2. [**Organic**] [**Compost**] Mulch: [**1-pint (0.5-L)**] [**1-quart (1-L)**] <**Insert value**> volume of each organic mulch required; in sealed plastic bags labeled with composition of materials by percentage of weight and source of mulch. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of color, texture, and organic makeup.
3. Mineral Mulch: [**2 lb (1.0 kg)**] [**5 lb (2.5 kg)**] <**Insert value**> of each mineral mulch required, in sealed plastic bags labeled with source of mulch. Sample shall be typical of the lot of material to be delivered and installed on-site; provide an accurate indication of color, texture, and makeup of the material.
4. Weed Control Barrier: 12 by 12 inches (300 by 300 mm).
5. Proprietary Root-Ball-Stabilization Device: One unit.
6. Slow-Release, Tree-Watering Device: One unit of each size required.
7. Edging Materials and Accessories: Manufacturer's standard size, to verify color selected.
8. Tree Grates[**, Frames,**] and Accessories: Manufacturer's standard size[ **delivered to site for review**], to verify design[ **and color**] selected.
9. Root Barrier: Width of panel by 12 inches (300 mm).

## 1.9 INFORMATIONAL SUBMITTALS

A. Qualification Data: For landscape Installer. Include list of similar projects completed by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.

B. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:

1. Manufacturer's certified analysis of standard products.
2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

C. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

D. Sample Warranty: For special warranty.

## 1.10 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of plants during a calendar year. Submit before expiration of required maintenance periods.

## 1.11 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of plants.

1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.

2. Experience: [**Three**] [**Five**] <**Insert number**> years' experience in landscape installation in addition to requirements in Section 014000 "Quality Requirements."
3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
4. Personnel Certifications: Installer's [**field supervisor**] [**personnel assigned to the Work**] shall have certification in [**one**] [**all**] of the following categories from the Professional Landcare Network:

    a. Landscape Industry Certified Technician - Exterior.
    b. Landscape Industry Certified Interior.
    c. Landscape Industry Certified Horticultural Technician.

5. Pesticide Applicator: State licensed, commercial.

B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.

1. Selection of plants purchased under allowances is made by Architect, who tags plants at their place of growth before they are prepared for transplanting.

C. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.

1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container-grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches (150 mm) above the root flare for trees up to 4-inch (100-mm) caliper size, and 12 inches (300 mm) above the root flare for larger sizes.
2. Other Plants: Measure with stems, petioles, and foliage in their normal position.

D. Plant Material Observation: Architect may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Architect may also observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and may reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.

1. Notify Architect of sources of planting materials [**seven**] <**Insert number**> days in advance of delivery to site.

## 1.12 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws if applicable.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.

2. 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.
3. Accompany each delivery of bulk materials with appropriate certificates.

C. Deliver bare-root stock plants within [**24 hours**] [**36 hours**] <**Insert time**> of digging. 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. Transport in covered, temperature-controlled vehicles, and keep plants cool and protected from sun and wind at all times.

D. 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.

E. Handle planting stock by root ball.

F. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F (16 to 18 deg C) until planting.

G. 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.

1. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after planting.

H. 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.

I. 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.

1. Heel-in bare-root stock. Soak roots that are in less than moist condition in water for two hours. Reject plants with dry roots.
2. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
3. Do not remove container-grown stock from containers before time of planting.
4. 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.

## 1.13 FIELD CONDITIONS

A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.

B. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.

1. Spring Planting: <**Insert dates**>.
2. Fall Planting: <**Insert dates**>.

C. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

## 1.14 WARRANTY

A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner.
b. Structural failures including plantings falling or blowing over.
c. Faulty performance of [**tree stabilization**] [**edgings**] [**and**] [**tree grates**] <**Insert item**>.
d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Periods: From date of [**planting completion**] [**Substantial Completion**] <**Insert starting time**>.

a. Trees, Shrubs, Vines, and Ornamental Grasses: [**12**] <**Insert number**> months.
b. Ground Covers, Biennials, Perennials, and Other Plants: [**12**] [**Nine**] [**Six**] [**Three**] <**Insert number**> months.
c. Annuals: [**Three**] [**Two**] <**Insert number**> months.

3. Include the following remedial actions as a minimum:

a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
c. A limit of one replacement of each plant is required except for losses or replacements due to failure to comply with requirements.
d. Provide extended warranty for period equal to original warranty period, for replaced plant material.

PART 2 - PRODUCTS

## 2.1 PLANT MATERIAL

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated 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.

1. 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 are unacceptable.
2. 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.

B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Architect, with a proportionate increase in size of roots or balls.

C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

D. Labeling: Label [**each**] [**at least one**] plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant.

E. If formal arrangements or consecutive order of plants is indicated on Drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.

F. [**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**].

## 2.2 FERTILIZERS

A. 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.

1. Size: [**5-gram**] [**10-gram**] [**21-gram**] <**Insert size**> tablets.
2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

## 2.3 MULCHES

A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:

1. Type: [**Shredded hardwood**] [**Ground or shredded bark**] [**Wood and bark chips**] [**Pine straw**] [**Salt hay or threshed straw**] [**Pine needles**] [**Peanut, pecan, and cocoa-bean shells**] <**Insert mulch type**>.
2. Size Range: [**3 inches (76 mm) maximum, 1/2 inch (13 mm) minimum**] <**Insert dimensions**>.
3. Color: Natural.

B. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through a 1-inch (25-mm) sieve; soluble-salt content of [**2 to 5**] <**Insert range or value**> dS/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

1. Organic Matter Content: [**50 to 60**] <**Insert number range**> percent of dry weight.
2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

C. Mineral Mulch: Hard, durable stone, washed free of loam, sand, clay, and other foreign substances, of the following type, size range, and color:

1. Type: [**Rounded riverbed gravel or smooth-faced stone**] [**Crushed stone or gravel**] [**Marble chips**] [**Granite chips**] <**Insert stone type**>.
2. Size Range: [**1-1/2 inches (38 mm) maximum, 3/4 inch (19 mm) minimum**] [**3/4 inch (19 mm) maximum, 1/4 inch (6.4 mm) minimum**] <**Insert dimensions**>.
3. Color: [**Uniform tan-beige color range acceptable to Architect**] [**Readily available natural gravel color range**] <**Insert color**>.

## 2.4 WEED-CONTROL BARRIERS

A. 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.

B. Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, 4.8 oz./sq. yd. (162 g/sq. m).

## 2.5 PESTICIDES

A. General: Pesticide registered and approved by the 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.

B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

## 2.6 TREE-STABILIZATION MATERIALS

A. Trunk-Stabilization Materials:

1. Upright and Guy Stakes: Rough-sawn, sound, new [**hardwood**] [**softwood with specified wood pressure-preservative treatment**], 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.
2. Wood Deadmen: Timbers measuring 8 inches (200 mm) in diameter and 48 inches (1200 mm) long, treated with specified wood pressure-preservative treatment.
3. Flexible Ties: Wide rubber or elastic bands or straps of length required to reach stakes or [**turnbuckles**] [**compression springs**].
4. 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.
5. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.
6. Guy Cables: Five-strand, 3/16-inch- (4.8-mm-) diameter, galvanized-steel cable, with zinc-coated [**turnbuckles**] [**compression springs**], a minimum of 3 inches (75 mm) long, with two 3/8-inch (10-mm) galvanized eyebolts.
7. Flags: Standard surveyor's plastic flagging tape, white, 6 inches (150 mm) long.
8. Proprietary Staking-and-Guying Devices: Proprietary stake or anchor and adjustable tie systems to secure each new planting by plant stem; sized as indicated and according to manufacturer's written recommendations.

    a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Root-Ball Stabilization Materials:

1. 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.
2. Wood Screws: ASME B18.6.1.
3. Proprietary Root-Ball Stabilization Devices: Proprietary at- or below-grade stabilization systems to secure each new planting by root ball and that do not encircle the trunk; sized according to manufacturer's written recommendations unless otherwise indicated.

    a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Palm Bracing: Battens or blocks, struts, straps, and protective padding.

1. 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.

2. Straps: Adjustable steel or plastic package banding.
3. Padding: Burlap.
4. Proprietary Palm-Bracing Devices: Proprietary systems to secure each new planting by trunk; sized according to manufacturer's written recommendations unless otherwise indicated.

    a. <Double click here to find, evaluate, and insert list of manufacturers and products.>

## 2.7 LANDSCAPE EDGINGS

A. Wood Edging: Of sizes indicated on Drawings, and wood stakes as follows:

1. Species: [**Western red cedar, all heart**] [**Southern pine with specified wood pressure-preservative treatment**].
2. 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.

B. Steel Edging: Standard commercial-steel edging, fabricated in sections of standard lengths, with loops stamped from or welded to face of sections to receive stakes.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Edging Size: [**3/16 inch (4.8 mm) thick by 4 inches (100 mm) deep**] [**1/4 inch (6.4 mm) thick by 5 inches (125 mm) deep**] [**1/4 inch (6.4 mm) thick by 4 inches (100 mm) deep**] [**1/8 inch (3.2 mm) thick by 4 inches (100 mm) deep**] [**1/8 inch (3.2 mm) thick by 6 inches (150 mm) deep**] [**0.1 inch (2.5 mm) thick by 4 inches (100 mm) deep**] <**Insert dimensions**>.
3. Stakes: Tapered steel, a minimum of [**12 inches (300 mm)**] [**15 inches (380 mm)**] <**Insert dimension**> long.
4. Accessories: Standard tapered ends, corners, and splicers.
5. Finish: [**Manufacturer's standard paint**] [**Zinc coated**] [**Unfinished**].

    a. Paint Color: [**Black**] [**Green**] [**Brown**].

C. 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.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Edging Size: [**3/16 inch (4.8 mm) thick by 5-1/2 inches (140 mm) deep**] [**3/16 inch (4.8 mm) thick by 4 inches (100 mm) deep**] [**1/8 inch (3.2 mm) thick by 5-1/2 inches (140 mm) deep**] [**1/8 inch (3.2 mm) thick by 4 inches (100 mm) deep**] <**Insert dimensions**>.
3. 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.
4. Finish: [**Manufacturer's standard paint**] [**Powder-coat paint**] [**Mill (natural aluminum)**] [**Black anodized**].

    a. Paint Color: [**Black**] [**Green**] [**Brown**].

D. Plastic Edging: Standard black polyethylene or vinyl edging, [**V-lipped bottom**] [**horizontally grooved**] <**Insert configuration**>, extruded in standard lengths, with 9-inch (225-mm) [**steel angle**] [**plastic**] stakes.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Edging Size: [**0.1 inch (2.5 mm) thick by 5 inches (125 mm) deep**] [**0.07 inch (1.8 mm) thick by 5 inches (125 mm) deep**] <**Insert dimensions**>.
3. Top Profile: Straight, with top 2 inches (50 mm) being 1/4 inch (6.4 mm) thick.
4. Top Profile: Round top, [**1/2 inch (13 mm)**] [**1 inch (25 mm)**] in diameter.
5. Accessories: Manufacturer's standard alignment clips or plugs.

## 2.8 TREE GRATES

A. Tree Grates: Manufacturer's [**standard**] [**custom designed**] tree grates[ **and frames**].

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Grates: ASTM A 48/A 48M, Class 35 (Class 250) or better, gray-iron castings.
3. Frames: [**ASTM A 48/A 48M, Class 35 (Class 250) or better, gray-iron castings**] [**or**] [**ASTM A 36/A 36M steel-angle, hot-dip galvanized,**] of shape, pattern, and size indicated.

B. Shape and Size: [**As indicated on Drawings**] [**Round, 36 inches (914 mm) in diameter**] [**Round, 72 inches (1828 mm) in diameter**] [**48 inches (1219 mm) square**] [**60 inches (1524 mm) square**] [**Rectangular, 36 by 60 inches (914 by 1524 mm)**] [**Rectangular, 48 by 72 inches (1219 by 1828 mm)**] <**Insert shape and dimensions**>.

C. Finish: [**As fabricated**] [**Powder-coat finish**] <**Insert finish**>.

1. Color: Low-gloss [**black**] [**dark brown**] [**dark green**] [**dark gray**] <**Insert color**>.

## 2.9 TREE-WATERING DEVICES

A. Watering Pipe: PVC pipe 4 inches (100 mm) in diameter, site-cut to length as required, and with snug-fitting removable cap.

B. Slow-Release Watering Device: Standard product manufactured for drip irrigation of plants and emptying its water contents over [**an extended time period**] [**two to nine hours**] [**two to three weeks**] <**Insert number or range**>; manufactured from UV-light-stabilized nylon-reinforced polyethylene sheet, PVC, or HDPE plastic.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Color: [**As selected by Architect from manufacturer's full range**] [**black**] [**dark chocolate**] [**green**] [**or**] [**tan**] <**Insert color**>.

## 2.10 MISCELLANEOUS PRODUCTS

A. Wood Pressure-Preservative Treatment: AWPA U1, Use Category UC4a; acceptable to authorities having jurisdiction, and containing no arsenic or chromium.

B. Root Barrier: Black, molded, modular panels [**18 inches (457 mm)**] [**24 inches (610 mm)**] <**Insert dimension**> high (deep), 85 mils (2.2 mm) thick, and with vertical root deflecting ribs protruding 3/4 inch (19 mm) out from panel surface; manufactured with minimum 50 percent recycled polyethylene plastic with UV inhibitors.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. 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.

D. Burlap: Non-synthetic, biodegradable.

E. Planter Drainage Gravel: Washed, sound crushed stone or gravel complying with [**ASTM D 448 for Size No. 8**] <**Insert requirements**>.

F. Planter Filter Fabric: [**Woven**] [**Nonwoven**] geotextile manufactured for separation applications and made of polypropylene, polyolefin, or polyester fibers or combination of them.

G. 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.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine areas to receive plants, with Installer present, for compliance with requirements and conditions affecting installation and performance of the Work.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Verify that plants and vehicles loaded with plants can travel to planting locations with adequate overhead clearance.
3. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
4. Uniformly moisten excessively dry soil that is not workable or which is dusty.

B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

## 3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

B. 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.

C. 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.

D. Lay out plants at locations directed by Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.

## 3.3 PLANTING AREA ESTABLISHMENT

A. General: Prepare planting area for soil placement and mix planting soil according to [**Section 329113 "Soil Preparation."**] [**Section 329115 "Soil Preparation (Performance Specification)."**]

B. Placing Planting Soil: [**Place and mix planting soil in-place over exposed subgrade**] [**Place manufactured planting soil over exposed subgrade**] [**Blend planting soil in place**] <**Insert requirement**>.

C. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

D. Application of Mycorrhizal Fungi: At time directed by Architect, broadcast dry product uniformly over prepared soil at application rate [**indicated on Drawings**] [**according to manufacturer's written recommendations**] <**Insert application rate**>.

## 3.4 EXCAVATION FOR TREES AND SHRUBS

A. Planting Pits and Trenches: Excavate circular planting pits.

1. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are unacceptable. 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.
2. Excavate approximately three times as wide as ball diameter for [**balled and burlapped**] [**balled and potted**] [**container-grown**] [**fabric bag-grown**] stock.
3. Excavate at least 12 inches (300 mm) wider than root spread and deep enough to accommodate vertical roots for bare-root stock.

4. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
5. 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.
6. Maintain angles of repose of adjacent materials to ensure stability. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
7. Maintain supervision of excavations during working hours.
8. Keep excavations covered or otherwise protected [**overnight**] [**after working hours**] [**when unattended by Installer's personnel**].
9. If drain tile is indicated on Drawings or required under planting areas, excavate to top of porous backfill over tile.

B. Backfill Soil: Subsoil and topsoil removed from excavations [**may**] [**may not**] be used as backfill soil unless otherwise indicated.

C. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

1. 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.

D. Drainage: Notify Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.

E. Fill excavations with water and allow to percolate away before positioning trees and shrubs.

## 3.5 TREE, SHRUB, AND VINE PLANTING

A. Inspection: At time of 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.

B. Roots: Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. Balled and Burlapped Stock: Set each plant plumb and in center of planting pit or trench with root flare [**1 inch (25 mm) above**] [**2 inches (50 mm) above**] <**Insert requirement**> adjacent finish grades.

1. Backfill: Planting soil <**Insert drawing designation**>.[ **For trees, use excavated soil for backfill.**]
2. 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.

3. 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.
4. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 inch (25 mm) from root tips; do not place tablets in bottom of the hole.

    a. Quantity: [**As indicated on Drawings**] [**Two per plant**] [**Three for each caliper inch of plant**] <**Insert requirement**>.

5. Continue backfilling process. Water again after placing and tamping final layer of soil.

D. [**Balled and Potted**] [**and**] [**Container-Grown**] Stock: Set each plant plumb and in center of planting pit or trench with root flare [**1 inch (25 mm) above**] [**2 inches (50 mm) above**] <**Insert requirement**> adjacent finish grades.

1. Backfill: Planting soil <**Insert drawing designation**>.[ **For trees, use excavated soil for backfill.**]
2. Carefully remove root ball from container without damaging root ball or plant.
3. 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.
4. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 inch (25 mm) from root tips; do not place tablets in bottom of the hole.

    a. Quantity: [**As indicated on Drawings**] [**Two per plant**] [**Three for each caliper inch of plant**] <**Insert requirement**>.

5. Continue backfilling process. Water again after placing and tamping final layer of soil.

E. Fabric Bag-Grown Stock: Set each plant plumb and in center of planting pit or trench with root flare [**1 inch (25 mm) above**] [**2 inches (50 mm) above**] <**Insert requirement**> adjacent finish grades.

1. Backfill: Planting soil <**Insert drawing designation**>.[ **For trees, use excavated soil for backfill.**]
2. 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.
3. 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.
4. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 inch (25 mm) from root tips; do not place tablets in bottom of the hole.

    a. Quantity: [**As indicated on Drawings**] [**Two per plant**] [**Three for each caliper inch of plant**] <**Insert requirement**>.

5. Continue backfilling process. Water again after placing and tamping final layer of soil.

F. Bare-Root Stock: Set and support each plant in center of planting pit or trench with root flare [**1 inch (25 mm) above**] [**2 inches (50 mm) above**] <**Insert requirement**> adjacent finish grade.

1. Backfill: Planting soil <**Insert drawing designation**>.[ **For trees, use excavated soil for backfill.**]
2. Spread roots without tangling or turning toward surface. Plumb before backfilling, and maintain plumb while working.
3. Carefully work backfill in layers around roots by hand. Bring roots into close contact with the soil.
4. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
5. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. 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.

    a. Quantity: [**As indicated on Drawings**] [**Two per plant**] [**Three for each caliper inch of plant**] <**Insert requirement**>.

6. Continue backfilling process. Water again after placing and tamping final layer of soil.

G. Watering Pipe: During backfilling, install watering pipe 4 feet (1.25 m) deep into the planting pit outside the root ball [**as indicated on Drawings**] [**and**] [**with top of pipe 1 inch (25 mm) above the mulched surface**].

H. Slopes: 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.

## 3.6 MECHANIZED TREE-SPADE PLANTING

A. Trees [**shall**] [**may**] 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 manufacturer's maximum size recommendation for the tree spade being used, whichever is smaller.

B. Use the same tree spade to excavate the planting hole as will be used to extract and transport the tree.

C. When extracting the tree, center the trunk within the tree spade and move tree with a solid ball of earth.

D. Cut exposed roots cleanly during transplanting operations.

E. Plant trees following procedures in "Tree, Shrub, and Vine Planting" Article.

F. Where possible, orient the tree in the same direction as in its original location.

## 3.7 TREE, SHRUB, AND VINE PRUNING

A. Remove only dead, dying, or broken branches. Do not prune for shape.

B. Prune, thin, and shape trees, shrubs, and vines as directed by Architect.

C. 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.

D. Do not apply pruning paint to wounds.

## 3.8 TREE STABILIZATION

A. Trunk Stabilization by Upright Staking and Tying: Install trunk stabilization as follows unless otherwise indicated:

1. 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 indicated on Drawings**] [**at least 72 inches (1830 mm)**] [**one-third of trunk height**] <**Insert dimension or requirement**> above grade. Set vertical stakes and space to avoid penetrating root balls or root masses.
2. Upright Staking and Tying: Stake trees with 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.
3. Support trees with bands of flexible ties at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.
4. 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.

B. Trunk Stabilization by Staking and Guying: Install trunk stabilization as follows unless otherwise indicated on Drawings. 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.

1. Site-Fabricated, Staking-and-Guying Method: Install no fewer than three guys spaced equally around tree.

    a. Securely attach guys to stakes 30 inches (760 mm) long, driven to grade. Adjust spacing to avoid penetrating root balls or root masses. Provide [**turnbuckle**] [**compression spring**] for each guy wire and tighten securely.
    b. For trees more than [**6 inches (150 mm) in caliper**] <**Insert size**>, anchor guys to wood deadmen buried at least 36 inches (900 mm) below grade. Provide [**turnbuckle**] [**compression spring**] for each guy wire and tighten securely.
    c. Support trees with bands of flexible ties at contact points with tree trunk and reaching to [**turnbuckle**] [**compression spring**]. Allow enough slack to avoid rigid restraint of tree.

d. Support trees with [**guy 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**] [**compression spring**]. Allow enough slack to avoid rigid restraint of tree.
e. Attach flags to each guy wire, 30 inches (760 mm) above finish grade.
f. Paint [**turnbuckles**] [**compression springs**] with luminescent white paint.

2. 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.

C. Root-Ball Stabilization: Install at- or below-grade stabilization system to secure each new planting by the root ball unless otherwise indicated.

1. 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.

a. Install stakes of length required to penetrate at least [**to the dimension indicated on Drawings**] [**18 inches (450 mm)**] <**Insert dimension**> below bottom of backfilled excavation. Saw stakes off at horizontal stake.
b. Install screws through horizontal hold-down and penetrating at least 1 inch (25 mm) into stakes. Predrill holes if necessary to prevent splitting wood.
c. Install second set of stakes on other side of root trunk for larger trees.

2. 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.

D. 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.

1. Site-Fabricated Palm-Bracing Method:

a. 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.
b. 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.

2. 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.

## 3.9 ROOT-BARRIER INSTALLATION

A. Install root barrier where trees are planted within [**60 inches (1500 mm)**] [**48 inches (1200 mm)**] <**Insert dimension**> of paving or other hardscape elements, such as walls, curbs, and walkways, unless otherwise indicated on Drawings.

B. Align root barrier [**vertically**] [**with bottom edge angled at 20 degrees away from the paving or other hardscape element**], and run it linearly along and adjacent to the paving or other hardscape elements to be protected from invasive roots.

C. Install root barrier continuously for a distance of [**60 inches (1500 mm)**] <**Insert dimension**> in each direction from the tree trunk, for a total distance of [**10 feet (3 m)**] <**Insert dimension**> per tree. If trees are spaced closer, use a single continuous piece of root barrier.

1. Position top of root barrier [**flush with finish grade**] [**1/2 inch (13 mm) above finish grade**] [**according to manufacturer's written recommendations**].
2. Overlap root barrier a minimum of 12 inches (300 mm) at joints.
3. Do not distort or bend root barrier during construction activities.
4. Do not install root barrier surrounding the root ball of tree.

## 3.10 PLACING SOIL IN PLANTERS

A. 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)**] [**6 inches (150 mm)**] <**Insert dimension**> 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.

B. Fill planter with planting soil <**Insert drawing designation**>. Place soil in lightly compacted layers to an elevation of 1-1/2 inches (38 mm) below top of planter, allowing natural settlement.

## 3.11 GROUND COVER AND PLANT PLANTING

A. Set out and space ground cover and plants other than trees, shrubs, and vines [**9 inches (225 mm) apart**] [**12 inches (300 mm) apart**] [**18 inches (450 mm) apart**] [**24 inches (600 mm) apart**] [**as indicated on Drawings**] in even rows with triangular spacing.

B. Use planting soil <**Insert drawing designation**> for backfill.

C. Dig holes large enough to allow spreading of roots.

D. For rooted cutting plants supplied in flats, plant each in a manner that minimally disturbs the root system but to a depth not less than two nodes.

E. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.

F. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

G. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

## 3.12 PLANTING AREA MULCHING

A. 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)**] [**12 inches (300mm)**] and secure seams with galvanized pins.

B. Mulch backfilled surfaces of planting areas and other areas indicated.

1. Trees[ **and Treelike Shrubs**] in Turf Areas: Apply [**organic**] [**mineral**] mulch ring of [**2-inch (50-mm)**] [**3-inch (75-mm)**] <**Insert dimension**> average thickness, with [**12-inch (300-mm)**] [**24-inch (600-mm)**] [**36-inch (900-mm)**] <**Insert dimension**> radius around trunks or stems. Do not place mulch within [**3 inches (75 mm)**] [**6 inches (150 mm)**] <**Insert distance**> of trunks or stems.
2. Organic Mulch in Planting Areas: Apply [**2-inch (50-mm)**] [**3-inch (75-mm)**] <**Insert dimension**> 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)**] [**6 inches (150 mm)**] <**Insert distance**> of trunks or stems.
3. Mineral Mulch in Planting Areas: Apply [**2-inch (50-mm)**] [**3-inch (75-mm)**] <**Insert dimension**> 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)**] [**6 inches (150 mm)**] <**Insert distance**> of trunks or stems.

## 3.13 EDGING INSTALLATION

A. 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.

B. 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.

C. Aluminum Edging: Install aluminum edging where indicated according to manufacturer's written instructions. Anchor with aluminum stakes spaced approximately [**36 inches (900 mm)**] [**48 inches (1200 mm)**] apart, driven below top elevation of edging.

D. Plastic Edging: Install plastic edging where indicated according to manufacturer's written instructions. Anchor with steel stakes spaced approximately [**36 inches (900 mm)**] [**48 inches (1200 mm)**] apart, driven through upper base grooves or V-lip of edging.

E. 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 indicated on Drawings**].

F. Mow-Strip Installation:

1. Excavate for mow strip[ **as indicated on Drawings**].
2. Compact subgrade uniformly beneath mow strip.
3. Apply nonselective, pre-emergent herbicide that inhibits growth of grass and weeds.
4. Install [**wood**] [**steel**] [**aluminum**] [**plastic**] edging, delineating the edge of mow strip.
5. Install weed-control barrier before mulching, covering area of mow strip, and overlapping and pinning edges of barrier at least 6 inches (150 mm) and according to manufacturer's written instructions.
6. Place indicated thickness of [**organic**] [**mineral**] mulch, fully covering weed barrier.
7. Rake mulch to a uniform surface level with adjacent finish grades.

## 3.14 TREE GRATE INSTALLATION

A. Tree Grates: Install according to manufacturer's written instructions. Set grate segments flush with adjoining surfaces. Shim from supporting substrate with soil-resistant plastic. Maintain a 3-inch- (75-mm-) minimum growth radius around base of tree; break away portions of casting, if necessary, according to manufacturer's written instructions.

## 3.15 INSTALLING SLOW-RELEASE WATERING DEVICE

A. Provide one device for each tree.

B. Place device on top of the mulch at base of tree stem and fill with water according to manufacturer's written instructions.

## 3.16 PLANT MAINTENANCE

A. 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.

B. 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.

C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices when possible to minimize use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

## 3.17 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents according to authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Pre-Emergent Herbicides (Selective and Nonselective): Apply to tree, shrub, and ground-cover areas according to manufacturer's written recommendations. Do not apply to seeded areas.

C. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

## 3.18 REPAIR AND REPLACEMENT

A. General: Repair or replace existing or new trees and other plants that are damaged by construction operations, in a manner approved by Architect.

1. Submit details of proposed pruning and repairs.
2. Perform repairs of damaged trunks, branches, and roots within 24 hours, if approved.
3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Architect.

B. Remove and replace trees that are more than [**25**] <**Insert number**> percent dead or in an unhealthy condition[ **before the end of the corrections period**] or are damaged during construction operations that Architect determines are incapable of restoring to normal growth pattern.

1. Provide new trees of same size as those being replaced for each tree of [**6 inches (150 mm)**] [**4 inches (100 mm)**] <**Insert dimension**> or smaller in caliper size.
2. Provide [**one**] [**two**] <**Insert number**> new tree(s) of [**6-inch (150-mm)**] [**4-inch (100-mm)**] <**Insert dimension**> caliper size for each tree being replaced that measures more than [**6 inches (150 mm)**] [**4 inches (100 mm)**] in caliper size.
3. Species of Replacement Trees: [**Same species being replaced**] [**Species selected by Architect**] <**Insert species**>.

## 3.19 CLEANING AND PROTECTION

A. During planting, keep adjacent paving and construction clean and work area in an orderly condition. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

C. 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.

D. After installation and before [**Substantial Completion**] <**Insert time**>, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

E. At time of Substantial Completion, verify that tree-watering devices are in good working order and leave them in place. Replace improperly functioning devices.

## 3.20 MAINTENANCE SERVICE

A. Maintenance Service for Trees and Shrubs: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. 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:

1. Maintenance Period: [**12**] [**Six**] [**Three**] months from date of [**planting completion**] [**Substantial Completion**] <**Insert starting time**>.

B. Maintenance Service for Ground Cover and Other Plants: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. 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:

1. Maintenance Period: [**Six**] [**Three**] months from date of [**planting completion**] [**Substantial Completion**] <**Insert starting time**>.

END OF SECTION 32 93 00

# SECTION 33 05 00 - COMMON WORK RESULTS FOR UTILITIES

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. This Section includes the following:

1. Piping joining materials.
2. Transition fittings.
3. Dielectric fittings.
4. Sleeves.
5. Identification devices.
6. Grout.
7. Flowable fill.
8. Piped utility demolition.
9. Piping system common requirements.
10. Equipment installation common requirements.
11. Painting.
12. Concrete bases.
13. Metal supports and anchorages.

### 1.3 DEFINITIONS

A. Exposed Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions.

B. Concealed Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

C. ABS: Acrylonitrile-butadiene-styrene plastic.

D. CPVC: Chlorinated polyvinyl chloride plastic.

E. PE: Polyethylene plastic.

F. PVC: Polyvinyl chloride plastic.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:

1. Dielectric fittings.
2. Identification devices.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 QUALITY ASSURANCE

A. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Steel Piping Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Comply with ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes 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.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.8 COORDINATION

A. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

B. Coordinate installation of identifying devices after completing covering and painting if devices are applied to surfaces.

C. Coordinate size and location of concrete bases. Formwork, reinforcement, and concrete requirements are specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**].

PART 2 - PRODUCTS

## 2.1 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness, unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. Solvent Cements for Joining Plastic Piping:

1. ABS Piping: ASTM D 2235.
2. CPVC Piping: ASTM F 493.
3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
4. PVC to ABS Piping Transition: ASTM D 3138.

H. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

## 2.2 TRANSITION FITTINGS

A. Transition Fittings, General: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

B. Transition Couplings NPS 1-1/2 (DN 40) and Smaller:

1. Underground Piping: Manufactured piping coupling or specified piping system fitting.
2. Aboveground Piping: Specified piping system fitting.

C. AWWA Transition Couplings NPS 2 (DN 50) and Larger:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: AWWA C219, metal sleeve-type coupling for underground pressure piping.

D. Plastic-to-Metal Transition Fittings:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: [**CPVC**] [**CPVC and PVC**] [**PVC**] one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint[ **or threaded**] end.

E. Plastic-to-Metal Transition Unions:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: MSS SP-107, [**CPVC**] [**CPVC and PVC**] [**PVC**] four-part union. Include brass[ **or stainless-steel**] threaded end, solvent-cement-joint[ **or threaded**] plastic end, rubber O-ring, and union nut.

F. Flexible Transition Couplings for Underground Nonpressure Drainage Piping:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

## 2.3 DIELECTRIC FITTINGS

A. Dielectric Fittings, General: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Factory fabricated, union, NPS 2 (DN 50) and smaller.

    a. Pressure Rating: [**150 psig (1035 kPa) minimum**] [**250 psig (1725 kPa)**] at 180 deg F (82 deg C).
    b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded ferrous.

C. Dielectric Flanges:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Factory-fabricated, bolted, companion-flange assembly, NPS 2-1/2 to NPS 4 (DN 65 to DN 100) and larger.

    a. Pressure Rating: [**150 psig (1035 kPa) minimum**] [**175 psig (1200 kPa) minimum**] [**300 psig (2070 kPa)**].
    b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Kits:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Nonconducting materials for field assembly of companion flanges, NPS 2-1/2 (DN 65) and larger.

   a. Pressure Rating: [**150 psig (1035 kPa) minimum**] <**Insert pressure**>.
   b. Gasket: Neoprene or phenolic.
   c. Bolt Sleeves: Phenolic or polyethylene.
   d. Washers: Phenolic with steel backing washers.

E. Dielectric Couplings:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining, NPS 3 (DN 80) and smaller.

   a. Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
   b. End Connections: Threaded.

F. Dielectric Nipples:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining.

   a. Pressure Rating: [**300 psig (2070 kPa) at 225 deg F (107 deg C)**] <**Insert pressure and temperature**>.
   b. End Connections: Threaded or grooved.

## 2.4 SLEEVES

A. Mechanical sleeve seals for pipe penetrations are specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

B. Galvanized-Steel Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

C. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized, plain ends.

D. Cast-Iron Sleeves: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

E. Molded PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.

F. PVC Pipe Sleeves: ASTM D 1785, Schedule 40.

G. Molded PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

## 2.5 IDENTIFICATION DEVICES

A. General: Products specified are for applications referenced in other utilities Sections. If more than single type is specified for listed applications, selection is Installer's option.

B. Equipment Nameplates: Metal permanently fastened to equipment with data engraved or stamped.

1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and essential data.
2. Location: Accessible and visible.

C. Stencils: Standard stencils prepared with letter sizes complying with recommendations in ASME A13.1. Minimum letter height is 1-1/4 inches (30 mm) for ducts, and 3/4 inch (20 mm) for access door signs and similar operational instructions.

1. Material: [**Fiberboard**] [**Brass**].
2. Stencil Paint: Exterior, oil-based, alkyd-gloss black enamel, unless otherwise indicated. Paint may be in pressurized spray-can form.
3. Identification Paint: Exterior, oil-based, alkyd enamel in colors according to ASME A13.1, unless otherwise indicated.

D. Snap-on Plastic Pipe Markers: Manufacturer's standard preprinted, semirigid, snap-on type. Include color-coding according to ASME A13.1, unless otherwise indicated.

E. Pressure-Sensitive Pipe Markers: Manufacturer's standard preprinted, color-coded, pressure-sensitive-vinyl type with permanent adhesive.

F. Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): Full-band pipe markers, extending 360 degrees around pipe at each location.

G. Pipes with OD, Including Insulation, 6 Inches (150 mm) and Larger: Either full-band or strip-type pipe markers, at least three times letter height and of length required for label.

H. Lettering: Manufacturer's standard preprinted captions as selected by Architect.

I. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.

1. Arrows: Either integrally with piping system service lettering to accommodate both directions of flow, or as separate unit on each pipe marker to indicate direction of flow.

J. Plastic Tape: Manufacturer's standard color-coded, pressure-sensitive, self-adhesive vinyl tape, at least 3 mils (0.08 mm) thick.

1. Width: 1-1/2 inches (40 mm) on pipes with OD, including insulation, less than 6 inches (150 mm); 2-1/2 inches (65 mm) for larger pipes.
2. Color: Comply with ASME A13.1, unless otherwise indicated.

K. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) sequenced numbers. Include 5/32-inch (4-mm) hole for fastener.

1. Material: 0.032-inch- (0.8-mm-) thick, [**polished brass**] [**or**] [**aluminum**].
2. Material: 0.0375-inch- (1-mm-) thick stainless steel.
3. Material: 3/32-inch- (2.4-mm-) thick plastic laminate with 2 black surfaces and a white inner layer.
4. Material: Valve manufacturer's standard solid plastic.
5. Size: 1-1/2 inches (40 mm) in diameter, unless otherwise indicated.
6. Shape: As indicated for each piping system.

L. Valve Tag Fasteners: Brass, wire-link or beaded chain; or brass S-hooks.

M. Engraved Plastic-Laminate Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.

1. Engraving: Engraver's standard letter style, of sizes and with terms to match equipment identification.
2. Thickness: [**1/16 inch (1.6 mm)**] [**1/8 inch (3 mm)**], unless otherwise indicated.
3. Thickness: 1/16 inch (1.6 mm), for units up to 20 sq. in. (130 sq. cm) or 8 inches (200 mm) in length, and 1/8 inch (3 mm) for larger units.
4. Fasteners: Self-tapping, stainless-steel screws or contact-type permanent adhesive.

N. Plastic Equipment Markers: Manufacturer's standard laminated plastic, in the following color codes:

1. Green: Cooling equipment and components.
2. Yellow: Heating equipment and components.
3. Brown: Energy reclamation equipment and components.
4. Blue: Equipment and components that do not meet criteria above.
5. Hazardous Equipment: Use colors and designs recommended by ASME A13.1.
6. Terminology: Match schedules as closely as possible. Include the following:

    a. Name and plan number.
    b. Equipment service.
    c. Design capacity.
    d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.

7. Size: 2-1/2 by 4 inches (65 by 100 mm) for control devices, dampers, and valves; 4-1/2 by 6 inches (115 by 150 mm) for equipment.

O. Plasticized Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with mat finish suitable for writing.

1. Size: 3-1/4 by 5-5/8 inches (83 by 143 mm).
2. Fasteners: Brass grommets and wire.
3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.

P. Lettering and Graphics: Coordinate names, abbreviations, and other designations used in piped utility identification with corresponding designations indicated. Use numbers, letters, and terms

indicated for proper identification, operation, and maintenance of piped utility systems and equipment.

1. Multiple Systems: Identify individual system number and service if multiple systems of same name are indicated.

## 2.6 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

## 2.7 FLOWABLE FILL

A. Description: Low-strength-concrete, flowable-slurry mix.

1. Cement: ASTM C 150, Type I, portland.
2. Density: [**115- to 145-lb/cu. ft. (1840- to 2325-kg/cu. m)**] <**Insert value**>.
3. Aggregates: ASTM C 33, natural sand, fine and crushed gravel or stone, coarse.
4. Aggregates: ASTM C 33, natural sand, fine.
5. Admixture: ASTM C 618, fly-ash mineral.
6. Water: Comply with ASTM C 94/C 94M.
7. Strength: [**100 to 200 psig (690 to 1380 kPa)**] <**Insert value**> at 28 days.

# PART 3 - EXECUTION

## 3.1 PIPED UTILITY DEMOLITION

A. Refer to Section 024119 "Selective Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove piped utility systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Drain piping. Fill abandoned piping with flowable fill, and cap or plug piping with same or compatible piping material.
3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make operational.
5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

## 3.2 DIELECTRIC FITTING APPLICATIONS

A. Dry Piping Systems: Connect piping of dissimilar metals with the following:

1. NPS 2 (DN 50) and Smaller: Dielectric unions.
2. NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Dielectric flanges[ **or dielectric flange kits**].

B. Wet Piping Systems: Connect piping of dissimilar metals with the following:

1. NPS 2 (DN 50) and Smaller: Dielectric [**couplings**] [**couplings or dielectric nipples**] [**nipples**].
2. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Dielectric nipples.
3. NPS 2-1/2 to NPS 8 (DN 65 to DN 200): Dielectric nipples[ **or dielectric flange kits**].
4. NPS 10 and NPS 12 (DN 250 and DN 300): Dielectric flange kits.

## 3.3 PIPING INSTALLATION

A. Install piping according to the following requirements and utilities Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. 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 on the Coordination Drawings.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping to permit valve servicing.

E. Install piping at indicated slopes.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Select system components with pressure rating equal to or greater than system operating pressure.

I. Sleeves are not required for core-drilled holes.

J. Permanent sleeves are not required for holes formed by removable PE sleeves.

K. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

    a. Exception: Extend sleeves installed in floors of equipment areas or other wet areas [**2 inches (50 mm)**] <**Insert dimension**> above finished floor level.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.

    a. [**PVC**] [**Steel**] Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
    b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.

L. Verify final equipment locations for roughing-in.

M. Refer to equipment specifications in other Sections for roughing-in requirements.

## 3.4 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and utilities Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. 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:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. 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.

E. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

G. Grooved Joints: Assemble joints with grooved-end pipe coupling with coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

H. Soldered Joints: Apply ASTM B 813 water-flushable flux, unless otherwise indicated, to tube end. 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.

I. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

J. Pressure-Sealed Joints: Assemble joints for plain-end copper tube and mechanical pressure seal fitting with proprietary crimping tool to according to fitting manufacturer's written instructions.

K. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 appendixes.
3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
4. 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.
5. PVC Nonpressure Piping: Join according to ASTM D 2855.
6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.

L. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

M. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

N. Plastic Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End PE Pipe and Fittings: Use butt fusion.
2. Plain-End PE Pipe and Socket Fittings: Use socket fusion.

O. Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

## 3.5 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Install dielectric fittings at connections of dissimilar metal pipes.

## 3.6 EQUIPMENT INSTALLATION

A. Install equipment level and plumb, unless otherwise indicated.

B. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference with other installations. Extend grease fittings to an accessible location.

C. Install equipment to allow right of way to piping systems installed at required slope.

## 3.7 PAINTING

A. Painting of piped utility systems, equipment, and components is specified in Section 099113 "Exterior Painting," Section 099123 "Interior Painting," and Section 099600 "High-Performance Coatings."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

## 3.8 IDENTIFICATION

A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.

1. Stenciled Markers: According to ASME A13.1.
2. Plastic markers, with application systems. Install on insulation segment if required for hot noninsulated piping.
3. Locate pipe markers on exposed piping according to the following:

    a. Near each valve and control device.
    b. Near each branch, excluding short takeoffs for equipment and terminal units. Mark each pipe at branch if flow pattern is not obvious.
    c. Near locations where pipes pass through walls or floors or enter inaccessible enclosures.
    d. At manholes and similar access points that permit view of concealed piping.
    e. Near major equipment items and other points of origination and termination.

B. Equipment: Install engraved plastic-laminate sign or equipment marker on or near each major item of equipment.

1. Lettering Size: Minimum 1/4 inch (6.4 mm) high for name of unit if viewing distance is less than 24 inches (610 mm), 1/2 inch (13 mm) high for distances up to 72 inches (1800 mm), and proportionately larger lettering for greater distances. Provide secondary lettering two-thirds to three-fourths of size of principal lettering.
2. Text of Signs: Provide name of identified unit. Include text to distinguish among multiple units, inform user of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

C. Adjusting: Relocate identifying devices that become visually blocked by work of this or other Divisions.

## 3.9 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.

2. 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 base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use [**3000-psi (20.7-MPa)**] <**Insert strength**>, 28-day compressive-strength concrete and reinforcement as specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**]

## 3.10 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Section 055000 "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor piped utility materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

## 3.11 GROUTING

A. Mix and install grout for equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 33 05 00

# SECTION 33 41 00 - STORM UTILITY DRAINAGE PIPING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. Section Includes:

1. Pipe and fittings.
2. Nonpressure transition couplings.
3. Pressure pipe couplings.
4. Expansion joints and deflection fittings.
5. Backwater valves.
6. Cleanouts.
7. Drains.
8. Encasement for piping.
9. Manholes.
10. Channel drainage systems.
11. Catch basins.
12. Stormwater inlets.
13. Stormwater detention structures.
14. Pipe outlets.

### 1.3 DEFINITIONS

A. FRP: Fiberglass-reinforced plastic.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings:

1. Manholes: Include plans, elevations, sections, details, frames, and covers.
2. Catch basins and stormwater inlets. Include plans, elevations, sections, details, frames, covers, and grates.
3. Stormwater Detention Structures: Include plans, elevations, sections, details, frames, covers, design calculations, and concrete design-mix reports.

1.5 INFORMATIONAL SUBMITTALS

A. 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.

B. 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.

C. Product Certificates: For each type of cast-iron soil pipe and fitting, from manufacturer.

D. Field quality-control reports.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic manholes, pipe, and fittings in direct sunlight.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

C. Handle manholes according to manufacturer's written rigging instructions.

D. Handle [**catch basins**] [**and**] [**stormwater inlets**] according to manufacturer's written rigging instructions.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify [**Architect**] [**Construction Manager**] [**Owner**] no fewer than [**two**] <**Insert number**> days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without [**Architect's**] [**Construction Manager's**] [**Owner's**] written permission.

PART 2 - PRODUCTS

2.1 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74, [**Service class**] [**Service and Extra-Heavy classes**] [**Extra-Heavy class**].

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

## 2.2 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. CISPI-Trademarked, Shielded Couplings:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. 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.

C. Heavy-Duty, Shielded Couplings:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. 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.

D. Cast-Iron, Shielded Couplings:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. 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.

## 2.3 DUCTILE-IRON, CULVERT PIPE AND FITTINGS

A. Pipe: ASTM A 716, 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.

## 2.4 DUCTILE-IRON, PRESSURE PIPE AND FITTINGS

A. Push-on-Joint Piping:

1. Pipe: AWWA C151, 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, of shape matching pipe and fittings.

B. Mechanical-Joint Piping:

1. Pipe: AWWA C151, with bolt holes in bell.
2. Standard Fittings: AWWA C110, ductile or gray iron, with bolt holes in bell.
3. Compact Fittings: AWWA C153, with bolt holes in bells.

4. Glands: Cast or ductile iron, with bolt holes and high-strength, cast-iron or high-strength, low-alloy steel bolts and nuts.
5. Gaskets: AWWA C111, rubber, of shape matching pipe, fittings, and glands.

## 2.5 PE PIPE AND FITTINGS

A. 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.

1. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with tube and fittings.
2. Soiltight Couplings: AASHTO M 252M, corrugated, matching tube and fittings.

B. 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.

1. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with pipe and fittings.
2. Soiltight Couplings: AASHTO M 294M, corrugated, matching pipe and fittings.

## 2.6 PVC PIPE AND FITTINGS

A. PVC Cellular-Core Piping:

1. 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.
2. Fittings: ASTM D 3034, [**SDR 35**] <**Insert SDR**>, PVC socket-type fittings.

B. PVC Corrugated Sewer Piping:

1. Pipe: ASTM F 949, PVC, corrugated pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: ASTM F 949, PVC molded or fabricated, socket type.
3. Gaskets: ASTM F 477, elastomeric seals.

C. PVC Profile Sewer Piping:

1. Pipe: ASTM F 794, PVC profile, gravity sewer pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: ASTM D 3034, PVC with bell ends.
3. Gaskets: ASTM F 477, elastomeric seals.

D. PVC Type PSM Sewer Piping:

1. Pipe: ASTM D 3034, [**SDR 35**] <**Insert SDR**>, PVC Type PSM sewer pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: ASTM D 3034, PVC with bell ends.
3. Gaskets: ASTM F 477, elastomeric seals.

E. PVC Gravity Sewer Piping:

1. Pipe and Fittings: ASTM F 679, [**T-1**] [**T-2**] wall thickness, PVC gravity sewer pipe with bell-and-spigot ends and with integral ASTM F 477, elastomeric seals for gasketed joints.

F. PVC Pressure Piping:

1. Pipe: AWWA C900, [**Class 100**] [**Class 150**] [**and**] [**Class 200**] PVC pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: AWWA C900, [**Class 100**] [**Class 150**] [**and**] [**Class 200**] PVC pipe with bell ends
3. Gaskets: ASTM F 477, elastomeric seals.

G. PVC Water-Service Piping:

1. Pipe: ASTM D 1785, [**Schedule 40**] [**and**] [**Schedule 80**] PVC, with plain ends for solvent-cemented joints.
2. Fittings: [**ASTM D 2466, Schedule 40**] [**and**] [**ASTM D 2467, Schedule 80**] PVC, socket type.

## 2.7 CONCRETE PIPE AND FITTINGS

A. Nonreinforced-Concrete Sewer Pipe and Fittings: ASTM C 14 (ASTM C 14M), [**Class 1**] [**Class 2**] [**Class 3**], with [**bell-and-spigot**] [**or**] [**tongue-and-groove**] ends and [**gasketed joints with ASTM C 443 (ASTM C 443M), rubber gaskets**] [**sealant joints with ASTM C 990 (ASTM C 990M), bitumen or butyl-rubber sealant**].

B. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76 (ASTM C 76M).

1. [**Bell-and-spigot**] [**or**] [**tongue-and-groove**] ends and [**gasketed joints with ASTM C 443 (ASTM C 443M), rubber gaskets**] [**sealant joints with ASTM C 990 (ASTM C 990M), bitumen or butyl-rubber sealant**]
2. Class I, [**Wall A**] [**Wall B**].
3. Class II, [**Wall A**] [**Wall B**] [**Wall C**].
4. Class III, [**Wall A**] [**Wall B**] [**Wall C**].
5. Class IV, [**Wall A**] [**Wall B**] [**Wall C**].
6. Class V, [**Wall B**] [**Wall C**].

## 2.8 NONPRESSURE TRANSITION COUPLINGS

A. 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.

B. Sleeve Materials:

1. For Concrete Pipes: ASTM C 443 (ASTM C 443M), rubber.
2. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
3. For Fiberglass Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
4. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.

5. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

C. Unshielded, Flexible Couplings:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Elastomeric sleeve with[ **stainless-steel shear ring and**] corrosion-resistant-metal tension band and tightening mechanism on each end.

D. Shielded, Flexible Couplings:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. 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.

E. Ring-Type, Flexible Couplings:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.

## 2.9 PRESSURE PIPE COUPLINGS

A. <Double click here to find, evaluate, and insert list of manufacturers and products.>

B. Description: AWWA C219, tubular-sleeve coupling, with center sleeve, gaskets, end rings, and bolt fasteners.

C. Metal, bolted, sleeve-type, reducing or transition coupling, for joining underground pressure piping. Include [**150-psig (1035-kPa)**] [**200-psig (1380-kPa)**] <**Insert value**> minimum pressure rating and ends sized to fit adjoining pipes.

D. Center-Sleeve Material: [**Manufacturer's standard**] [**Carbon steel**] [**Stainless steel**] [**Ductile iron**] [**Malleable iron**].

E. Gasket Material: Natural or synthetic rubber.

F. Metal Component Finish: Corrosion-resistant coating or material.

## 2.10 EXPANSION JOINTS AND DEFLECTION FITTINGS

A. Ductile-Iron Flexible Expansion Joints:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. 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.

B. Ductile-Iron Expansion Joints:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. 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.

C. Ductile-Iron Deflection Fittings:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. 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.

## 2.11 BACKWATER VALVES

A. Cast-Iron Backwater Valves:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: ASME A112.14.1, gray-iron body and bolted cover, with bronze seat.
3. Horizontal type; with swing check valve and hub-and-spigot ends.
4. Combination horizontal and manual gate-valve type; with swing check valve, integral gate valve, and hub-and-spigot ends.
5. Terminal type; with bronze seat, swing check valve, and hub inlet.

B. Plastic Backwater Valves:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: Horizontal type; with PVC body, PVC removable cover, and PVC swing check valve.

## 2.12 CLEANOUTS

A. Cast-Iron Cleanouts:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. 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.
3. Top-Loading Classification(s): [**Light Duty**] [**Medium Duty**] [**Heavy Duty**] [**and**] [**Extra-Heavy Duty**].
4. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.

B. Plastic Cleanouts:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Description: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

## 2.13 DRAINS

A. Cast-Iron Area Drains:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: ASME A112.6.3 gray-iron round body with anchor flange and round[ **secured**] grate. Include bottom outlet with inside calk or spigot connection, of sizes indicated.
3. Top-Loading Classification(s): [**Medium Duty**] [**Medium and Heavy Duty**] [**Heavy Duty**].

B. Cast-Iron Trench Drains:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: ASME A112.6.3, 6-inch- (150-mm-) wide top surface, rectangular body with anchor flange or other anchoring device, and rectangular[ **secured**] grate. Include units of total length indicated and quantity of bottom outlets with inside calk or spigot connections, of sizes indicated.
3. Top-Loading Classification(s): [**Medium Duty**] [**Heavy Duty**] [**Extra-Heavy Duty**] [**Medium and Heavy Duty**] [**Medium and Extra-Heavy Duty**] [**Heavy and Extra-Heavy Duty**] [**Medium, Heavy, and Extra-Heavy Duty**].

C. Steel Trench Drains:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. 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.
3. Plate Thicknesses: [**1/8 inch (3.2 mm)**] [**1/8 inch (3.2 mm) and 1/4 inch (6.4 mm)**] [**1/4 inch (6.4 mm)**].
4. Overall Widths: [**7-1/2 inches (190 mm)**] [**7-1/2 inches (190 mm) and 12-1/3 inches (313 mm)**] [**12-1/3 inches (313 mm)**].

    a. Grate Openings: [**1/4 inch (6.4 mm) circular**] [**3/8 inch (9.5 mm) circular**] [**3/8 inch (9.5 mm) circular or 3/8-by-3-inch (9.5-by-76-mm) slots**] [**3/8-by-3-inch (9.5-by-76-mm) slots**].

## 2.14 ENCASEMENT FOR PIPING

A. Standard: ASTM A 674 or AWWA C105.

B. 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)**] minimum thickness.

C. Form: [**Sheet**] [**or**] [**tube**].

D. Color: [**Black**] [**or**] [**natural**] <**Insert color**>.

## 2.15 MANHOLES

A. Standard Precast Concrete Manholes:

1. Description: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.
2. Diameter: 48 inches (1200 mm) minimum unless otherwise indicated.
3. Ballast: Increase thickness of precast concrete sections or add concrete to base section as required to prevent flotation.
4. 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.
5. Riser Sections: 4-inch (102-mm) minimum thickness, and lengths to provide depth indicated.
6. 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.
7. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
8. Resilient Pipe Connectors: ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection.
9. Steps: [**Individual FRP steps or FRP ladder**] [**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**] [**ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP**] <**Insert material**>, 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)**] <**Insert dimension**>.
10. 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.
11. 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.

B. Designed Precast Concrete Manholes:

1. 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.
2. Ballast: Increase thickness of one or more precast concrete sections or add concrete to manhole as required to prevent flotation.
3. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
4. Resilient Pipe Connectors: ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection.

5. Steps: [**Individual FRP steps or FRP ladder**] [**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**] [**ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP**] <**Insert material**>, 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)**] <**Insert dimension**>.
6. 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.
7. 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.

C. Fiberglass Manholes:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Description: ASTM D 3753.
3. Diameter: 48 inches (1200 mm) minimum unless otherwise indicated.
4. Ballast: Increase thickness of concrete base as required to prevent flotation.
5. Base Section: Concrete, 6-inch (150-mm) minimum thickness.
6. Resilient Pipe Connectors: ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection.
7. 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)**] <**Insert dimension**>.
8. 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.
9. 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.

D. Manhole Frames and Covers:

1. 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."
2. Material: [**ASTM A 536, Grade 60-40-18 ductile**] [**ASTM A 48/A 48M, Class 35 gray**] iron unless otherwise indicated.

## 2.16 CONCRETE

A. General: Cast-in-place concrete according to ACI 318, ACI 350/350R (ACI 350M/350RM), and the following:

1. Cement: ASTM C 150, Type II.
2. Fine Aggregate: ASTM C 33, sand.
3. Coarse Aggregate: ASTM C 33, crushed gravel.
4. Water: Potable.

B. Portland Cement Design Mix: 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio.

1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

C. 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.

1. 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.

    a. Invert Slope: [**1**] [**2**] percent through manhole.

2. Benches: Concrete, sloped to drain into channel.

    a. Slope: [**4**] [**8**] percent.

D. Ballast and Pipe Supports: Portland cement design mix, 3000 psi (20.7 MPa) minimum, with 0.58 maximum water/cementitious materials ratio.

1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

## 2.17 POLYMER-CONCRETE, CHANNEL DRAINAGE SYSTEMS

A. 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.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Sloped-Invert, Polymer-Concrete Systems:

1. Channel Sections:

    a. Interlocking-joint, precast, modular units with end caps.

b. 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.
c. Extension sections necessary for required depth.
d. Frame: Include gray-iron or steel frame for grate.

2. Grates:

a. Manufacturer's designation "[**Heavy**] [**Medium**] Duty," with slots or perforations that fit recesses in channels.
b. Material: [**Fiberglass**] [**Galvanized steel**] [**Gray iron**] [**Stainless steel**].

3. Covers: Solid gray iron if indicated.
4. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.

D. Narrow-Width, Level-Invert, Polymer-Concrete Systems:

1. Channel Sections:

a. Interlocking-joint, precast, modular units with end caps.
b. 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.

2. Grates:

a. Slots or perforations that fit recesses in channels.
b. Material: [**Fiberglass**] [**Galvanized steel**] [**Gray iron**] [**Stainless steel**].

3. Covers: Solid gray iron if indicated.
4. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.

E. Wide-Width, Level-Invert, Polymer-Concrete Systems:

1. Channel Sections:

a. Interlocking-joint, precast, modular units with end caps.
b. 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.

2. Grates:

a. Slots or other openings that fit recesses in channels.
b. Material: [**Fiberglass**] [**Gray iron**].

3. Covers: Solid gray iron if indicated.
4. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.

F. Drainage Specialties: Precast, polymer-concrete units.

1. Large Catch Basins:

   a. 24-by-12-inch (610-by-305-mm) polymer-concrete body, with outlets in quantities and sizes indicated.
   b. Gray-iron slotted grate.
   c. Frame: Include gray-iron or steel frame for grate.

2. Small Catch Basins:

   a. 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.
   b. Gray-iron slotted grate.
   c. Frame: Include gray-iron or steel frame for grate.

3. Oil Interceptors:

   a. Polymer-concrete body with interior baffle and four steel support channels and two 1/4-inch- (6.4-mm-) thick, steel-plate covers.
   b. Steel-plate covers.
   c. Capacity: [**140 gal. (530 L)**] [**200 gal. (757 L)**] [**260 gal. (984 L)**].
   d. Inlet and Outlet: [**NPS 4 (DN 100)**] [**NPS 6 (DN 150)**].

4. Sediment Interceptors:

   a. 27-inch- (686-mm-) square, polymer-concrete body, with outlets in quantities and sizes indicated.
   b. 24-inch- (610-mm-) square, gray-iron frame and slotted grate.

G. Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.

H. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

## 2.18 PLASTIC, CHANNEL DRAINAGE SYSTEMS

A. General Requirements for Plastic, Channel Drainage Systems:

1. Modular system of plastic channel sections, grates, and appurtenances.
2. Designed so grates fit into frames without rocking or rattling.
3. Number of units required to form total lengths indicated.

B. <Double click here to find, evaluate, and insert list of manufacturers and products.>

C. Fiberglass Systems:

1. Channel Sections:

   a. Interlocking-joint, fiberglass modular units, with built-in invert slope of approximately 1 percent and with end caps.
   b. Rounded or inclined inside bottom surface, with outlets in quantities, sizes, and locations indicated.

c. Width: [**6 inches (150 mm)**] [**6 or 8 inches (150 or 203 mm)**] [**8 inches (203 mm)**].

2. Factory- or field-attached frames that fit channel sections and grates.

a. Material: [**Galvanized steel**] [**Stainless steel**] [**Manufacturer's standard metal**].

3. Grates with slots or perforations that fit frames.

a. Material: [**Fiberglass**] [**Galvanized steel**] [**Gray iron**] [**Stainless steel**].

4. Covers: Solid gray iron if indicated.
5. Drainage Specialties:

a. Large Catch Basins: 24-inch- (610-mm-) square plastic body, with outlets in quantities and sizes indicated. Include gray-iron frame and slotted grate.
b. 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.

D. PE Systems:

1. 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.
2. Grates: PE, ladder shaped; with stainless-steel screws.
3. Color: Gray unless otherwise indicated.
4. Drainage Specialties: Include the following PE components:

a. Drains: 4-inch- (102-mm-) diameter, round, slotted top; with NPS 4 (DN 100) bottom outlet.
b. Drains: 8-inch- (203-mm-) diameter, round, slotted top; with NPS 6 (DN 150) bottom outlet.
c. Drains: 4-inch- (102-mm-) square, slotted top; with NPS 3 (DN 80) bottom outlet.
d. Drains: 8-inch- (203-mm-) square, slotted top; with NPS 6 (DN 150) bottom outlet.
e. 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.

E. Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.

F. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

## 2.19 CATCH BASINS

A. Standard Precast Concrete Catch Basins:

1. Description: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.

2. 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.
3. Riser Sections: 4-inch (102-mm) minimum thickness, 48-inch (1200-mm) diameter, and lengths to provide depth indicated.
4. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
5. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
6. 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.
7. 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.
8. Steps: [**Individual FRP steps or FRP ladder**] [**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**] [**ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP**] <**Insert material**>, 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)**] <**Insert dimension**>.
9. Pipe Connectors: ASTM C 923 (ASTM C 923M), resilient, of size required, for each pipe connecting to base section.

B. 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.

1. Joint Sealants: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
2. 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.
3. 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.
4. Steps: [**Individual FRP steps or FRP ladder**] [**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**] [**ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP**] <**Insert material**>, 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)**] <**Insert dimension**>.
5. Pipe Connectors: ASTM C 923 (ASTM C 923M), resilient, of size required, for each pipe connecting to base section.

C. Frames and Grates: 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.

1. Size: 24 by 24 inches (610 by 610 mm) minimum unless otherwise indicated.
2. Grate Free Area: Approximately 50 percent unless otherwise indicated.

D. Frames and Grates: 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.

1. Grate Free Area: Approximately 50 percent unless otherwise indicated.

## 2.20 STORMWATER INLETS

A. Curb Inlets: Made with vertical curb opening[**, of materials and dimensions according to utility standards**].

B. Gutter Inlets: Made with horizontal gutter opening[**, of materials and dimensions according to utility standards**]. Include heavy-duty frames and grates.

C. Combination Inlets: Made with vertical curb and horizontal gutter openings[**, of materials and dimensions according to utility standards**]. Include heavy-duty frames and grates.

D. Frames and Grates: Heavy duty[**, according to utility standards**].

## 2.21 STORMWATER DETENTION STRUCTURES

A. 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.

1. Ballast: Increase thickness of concrete as required to prevent flotation.
2. Grade Rings: 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.
3. Steps: [**Individual FRP steps or FRP ladder**] [**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**] [**ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP**] <**Insert material**>, 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)**] <**Insert dimension**>.

B. 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."

## 2.22 PIPE OUTLETS

A. Head Walls: Cast-in-place reinforced concrete, with apron and tapered sides.

B. Riprap Basins: Broken, irregularly sized and shaped, graded stone according to NSSGA's "Quarried Stone for Erosion and Sediment Control."

1. Average Size: NSSGA No. R-3, screen opening 2 inches (51 mm).
2. Average Size: NSSGA No. R-4, screen opening 3 inches (76 mm).
3. Average Size: NSSGA No. R-5, screen opening 5 inches (127 mm).

C. Filter Stone: According to NSSGA's "Quarried Stone for Erosion and Sediment Control," No. FS-2, No. 4 screen opening, average-size graded stone.

D. 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.

## PART 3 - EXECUTION

### 3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Section 312000 "Earth Moving."

### 3.2 PIPING INSTALLATION

A. 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.

B. 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.

C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

D. 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.

E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.

F. Install gravity-flow, nonpressure drainage piping according to the following:

1. Install piping pitched down in direction of flow.
2. Install piping [**NPS 6 (DN 150)**] <**Insert value**> 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.
3. Install piping with [**36-inch (915-mm)**] [**48-inch (1220-mm)**] [**60-inch (1520-mm)**] [**72-inch (1830-mm)**] <**Insert dimension**> minimum cover.

4. Install hub-and-spigot, cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
5. Install hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
6. Install ductile-iron piping and special fittings according to AWWA C600 or AWWA M41.
7. Install PE corrugated sewer piping according to ASTM D 2321.
8. Install PVC cellular-core piping according to ASTM D 2321 and ASTM F 1668.
9. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.
10. Install PVC profile gravity sewer piping according to ASTM D 2321 and ASTM F 1668.
11. Install PVC water-service piping according to ASTM D 2321 and ASTM F 1668.
12. Install reinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."

G. Install force-main pressure piping according to the following:

1. 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.
2. Install piping with [**36-inch (915-mm)**] [**48-inch (1220-mm)**] [**60-inch (1520-mm)**] [**72-inch (1830-mm)**] <**Insert dimension**> minimum cover.
3. Install ductile-iron pressure piping according to AWWA C600 or AWWA M41.
4. Install ductile-iron special fittings according to AWWA C600.
5. Install PVC pressure piping according to AWWA M23, or ASTM D 2774 and ASTM F 1668.
6. Install PVC water-service piping according to ASTM D 2774 and ASTM F 1668.

H. Install corrosion-protection piping encasement over the following underground metal piping according to ASTM A 674 or AWWA C105:

1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Hubless cast-iron soil pipe and fittings.
3. Ductile-iron pipe and fittings.
4. Expansion joints and deflection fittings.

## 3.3 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure drainage piping according to the following:

1. 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.
2. 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.
3. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
4. Join ductile-iron culvert piping according to AWWA C600 for push-on joints.
5. Join ductile-iron piping and special fittings according to AWWA C600 or AWWA M41.
6. Join corrugated PE piping according to ASTM D 3212 for push-on joints.
7. Join PVC cellular-core piping according to ASTM D 2321 and ASTM F 891 for solvent-cemented joints.

8. Join PVC corrugated sewer piping according to ASTM D 2321 for elastomeric-seal joints.
9. 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.
10. Join PVC profile gravity sewer piping according to ASTM D 2321 for elastomeric-seal joints or ASTM F 794 for gasketed joints.
11. Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
12. Join dissimilar pipe materials with nonpressure-type flexible couplings.

B. Join force-main pressure piping according to the following:

1. Join ductile-iron pressure piping according to AWWA C600 or AWWA M41 for push-on joints.
2. Join ductile-iron special fittings according to AWWA C600 or AWWA M41 for push-on joints.
3. Join PVC pressure piping according to AWWA M23 for gasketed joints.
4. Join PVC water-service piping according to ASTM D 2855 for solvent-cemented joints.
5. Join dissimilar pipe materials with pressure-type couplings.

## 3.4 BACKWATER VALVE INSTALLATION

A. Install horizontal-type backwater valves in piping where indicated.

B. Install combination horizontal and manual gate-valve type in piping and in manholes where indicated.

C. Install terminal-type backwater valves on end of piping and in manholes where indicated.

## 3.5 CLEANOUT INSTALLATION

A. 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.

1. Use Light-Duty, top-loading classification cleanouts in [**earth or unpaved foot-traffic**] <**Insert other**> areas.
2. Use Medium-Duty, top-loading classification cleanouts in [**paved foot-traffic**] <**Insert other**> areas.
3. Use Heavy-Duty, top-loading classification cleanouts in [**vehicle-traffic service**] <**Insert other**> areas.
4. Use Extra-Heavy-Duty, top-loading classification cleanouts in [**roads**] <**Insert area**>.

B. 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)**] <**Insert dimensions**> deep. Set with tops [**1 inch (25 mm)**] <**Insert dimension**> above surrounding earth grade.

C. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

## 3.6 DRAIN INSTALLATION

A. Install type of drains in locations indicated.

1. Use Light-Duty, top-loading classification drains in [**earth or unpaved foot-traffic**] <**Insert other**> areas.
2. Use Medium-Duty, top-loading classification drains in [**paved foot-traffic**] <**Insert other**> areas.
3. Use Heavy-Duty, top-loading classification drains in [**vehicle-traffic service**] <**Insert other**> areas.
4. Use Extra-Heavy-Duty, top-loading classification drains in [**roads**] <**Insert area**>.

B. Embed drains in 4-inch (102-mm) minimum concrete around bottom and sides.

C. Fasten grates to drains if indicated.

D. Set drain frames and covers with tops flush with pavement surface.

E. Assemble trench sections with flanged joints.

F. Embed trench sections in [**4-inch (102-mm)**] <**Insert dimension**> minimum concrete around bottom and sides.

## 3.7 MANHOLE INSTALLATION

A. General: Install manholes, complete with appurtenances and accessories indicated.

B. Install precast concrete manhole sections with sealants according to ASTM C 891.

C. Where specific manhole construction is not indicated, follow manhole manufacturer's written instructions.

D. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops [**3 inches (76 mm)**] <**Insert dimension**> above finished surface elsewhere unless otherwise indicated.

## 3.8 CATCH BASIN INSTALLATION

A. Construct catch basins to sizes and shapes indicated.

B. Set frames and grates to elevations indicated.

## 3.9 STORMWATER INLET[ **AND OUTLET**] INSTALLATION

A. Construct inlet head walls, aprons, and sides of reinforced concrete, as indicated.

B. Construct riprap of broken stone, as indicated.

C. Install outlets that spill onto grade, anchored with concrete, where indicated.

D. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.

E. Construct energy dissipaters at outlets, as indicated.

## 3.10 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to ACI 318.

## 3.11 CHANNEL DRAINAGE SYSTEM INSTALLATION

A. Install with top surfaces of components, except piping, flush with finished surface.

B. Assemble channel sections to form slope down toward drain outlets. Use sealants, adhesives, fasteners, and other materials recommended by system manufacturer.

C. Embed channel sections and drainage specialties in [**4-inch (102-mm)**] <**Insert dimension**> minimum concrete around bottom and sides.

D. Fasten grates to channel sections if indicated.

E. Assemble channel sections with flanged or interlocking joints.

F. Embed channel sections in [**4-inch (102-mm)**] <**Insert dimension**> minimum concrete around bottom and sides.

## 3.12 CONNECTIONS

A. Connect nonpressure, gravity-flow drainage piping in building's storm building drains specified in Section 221413 "Facility Storm Drainage Piping."

B. Connect force-main piping to building's storm drainage force mains specified in Section 221413 "Facility Storm Drainage Piping." Terminate piping where indicated.

C. Make connections to existing piping and underground manholes.

1. 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).
2. 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).
3. 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.

a. Use concrete that will attain a minimum 28-day compressive strength of 3000 psi (20.7 MPa) unless otherwise indicated.
b. Use epoxy-bonding compound as interface between new and existing concrete and piping materials.

4. 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.

D. Connect to sediment interceptors specified in Section 221323 "Sanitary Waste Interceptors."

E. 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.

1. Use nonpressure-type flexible couplings where required to join gravity-flow, nonpressure sewer piping unless otherwise indicated.

a. [**Unshielded**] [**Shielded**] flexible couplings for same or minor difference OD pipes.
b. Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.
c. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.

2. Use pressure-type pipe couplings for force-main joints.

## 3.13 CLOSING ABANDONED STORM DRAINAGE SYSTEMS

A. 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:

1. Close open ends of piping with at least [**8-inch- (203-mm-)**] <**Insert dimension**> thick, brick masonry bulkheads.
2. 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.

B. Abandoned Manholes and Structures: Excavate around manholes and structures as required and use one procedure below:

1. Remove manhole or structure and close open ends of remaining piping.
2. Remove top of manhole or structure down to at least [**36 inches (915 mm)**] <**Insert dimension**> below final grade. Fill to within [**12 inches (300 mm)**] <**Insert dimension**> of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.

C. Backfill to grade according to Section 312000 "Earth Moving."

## 3.14 IDENTIFICATION

A. Materials and their installation are specified in Section 312000 "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.

1. Use[ **warning tape or**] detectable warning tape over ferrous piping.
2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

## 3.15 FIELD QUALITY CONTROL

A. 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.

1. Submit separate reports for each system inspection.
2. Defects requiring correction include the following:

    a. Alignment: Less than full diameter of inside of pipe is visible between structures.
    b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
    c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
    d. Infiltration: Water leakage into piping.
    e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to requirements of authorities having jurisdiction.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
4. Submit separate report for each test.
5. Gravity-Flow Storm Drainage Piping: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:

    a. Exception: Piping with soiltight joints unless required by authorities having jurisdiction.
    b. Option: Test plastic piping according to ASTM F 1417.
    c. Option: Test concrete piping according to ASTM C 924 (ASTM C 924M).

6. 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)**] <**Insert value**>.

a. Ductile-Iron Piping: Test according to AWWA C600, "Hydraulic Testing" Section.
b. PVC Piping: Test according to AWWA M23, "Testing and Maintenance" Chapter.

C. Leaks and loss in test pressure constitute defects that must be repaired.

D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.16 CLEANING

A. Clean interior of piping of dirt and superfluous materials.[ **Flush with potable water.**] [ **Flush with water.**]

END OF SECTION 33 41 00

# SECTION 33 46 00 - SUBDRAINAGE

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. Section Includes:

1. Perforated-wall pipe and fittings.
2. Drainage conduits.
3. Drainage panels.
4. Geotextile filter fabrics.

### 1.3 ACTION SUBMITTALS

A. Product Data:

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

## PART 2 - PRODUCTS

### 2.1 PERFORATED-WALL PIPES AND FITTINGS

A. Perforated PE Pipe and Fittings:

1. NPS 6 (DN 150) and Smaller: ASTM F 405 or AASHTO M 252, Type CP; corrugated, for coupled joints.
2. NPS 8 (DN 200) and Larger: ASTM F 667; AASHTO M 252, Type CP; or AASHTO M 294, Type CP; corrugated; for coupled joints.
3. Couplings: Manufacturer's standard, band type.

B. Perforated PVC Sewer Pipe and Fittings: ASTM D 2729, bell-and-spigot ends, for loose joints.

### 2.2 DRAINAGE CONDUITS

A. Molded-Sheet Drainage Conduits: Prefabricated geocomposite with cuspated, molded-plastic drainage core wrapped in geotextile filter fabric.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Nominal Size: 12 inches (305 mm) high by approximately 1 inch (25 mm) thick.

   a. Minimum In-Plane Flow: [**30 gpm (114 L/min.)**] <**Insert value**> at hydraulic gradient of [**1.0**] <**Insert value**> when tested according to ASTM D 4716.

3. Nominal Size: 18 inches (457 mm) high by approximately 1 inch (25 mm) thick.

   a. Minimum In-Plane Flow: [**45 gpm (170 L/min.)**] <**Insert value**> at hydraulic gradient of [**1.0**] <**Insert value**> when tested according to ASTM D 4716.

4. Filter Fabric: PP geotextile.
5. Fittings: HDPE with combination NPS 4 and NPS 6 (DN 100 and DN 150) outlet connection.

B. 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.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Nominal Size: 6 inches (152 mm) high by approximately 1-1/4 inches (31 mm) thick.

   a. Minimum In-Plane Flow: [**15 gpm (57 L/min.)**] <**Insert value**> at hydraulic gradient of [**1.0**] <**Insert value**> when tested according to ASTM D 4716.

3. Nominal Size: 12 inches (305 mm) high by approximately 1-1/4 inches (31 mm) thick.

   a. Minimum In-Plane Flow: [**30 gpm (114 L/min.)**] <**Insert value**> at hydraulic gradient of [**1.0**] <**Insert value**> when tested according to ASTM D 4716.

4. Nominal Size: 18 inches (457 mm) high by approximately 1-1/4 inches (31 mm) thick.

   a. Minimum In-Plane Flow: [**45 gpm (170 L/min.)**] <**Insert value**> at hydraulic gradient of [**1.0**] <**Insert value**> when tested according to ASTM D 4716.

5. Filter Fabric: Nonwoven, needle-punched geotextile.
6. Fittings: HDPE with combination NPS 4 and NPS 6 (DN 100 and DN 150) outlet connection.
7. Couplings: HDPE.

C. Single-Pipe Drainage Conduits: Prefabricated geocomposite with perforated corrugated core molded from HDPE complying with ASTM D 3350 and wrapped in geotextile filter fabric.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Nominal Size: 12 inches (305 mm) high by approximately 1 inch (25 mm) thick.

   a. Minimum In-Plane Flow: [**30 gpm (114 L/min.)**] <**Insert value**> at hydraulic gradient of [**1.0**] <**Insert value**> when tested according to ASTM D 4716.

3. Nominal Size: 18 inches (457 mm) high by approximately 1 inch (25 mm) thick.

    a. Minimum In-Plane Flow: [**45 gpm (170 L/min.)**] <**Insert value**> at hydraulic gradient of [**1.0**] <**Insert value**> when tested according to ASTM D 4716.

4. Filter Fabric: PP geotextile.
5. Fittings: HDPE with combination NPS 4 and NPS 6 (DN 100 and DN 150) outlet connection.
6. Couplings: Corrugated HDPE band.

D. 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.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Nominal Size: 6 inches (150-mm) high by approximately 0.9 inch (23 mm) thick.

    a. Minimum In-Plane Flow: [**2.4 gpm (9.1 L/min.)**] <**Insert value**> at hydraulic gradient of [**1.0**] <**Insert value**> when tested according to ASTM D 4716.

3. 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.

E. 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.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>

2. Nominal Size: 18 inches (0.5 m) high by 1 inch (25 mm) thick.

    a. Minimum In-Plane Flow: [**82 gpm (310 L/min.)**] <**Insert value**> at hydraulic gradient of [**1.0**] <**Insert value**> when tested according to ASTM D 4716.

3. Nominal Size: 36 inches (1 m) high by 1 inch (25 mm) thick.

    a. Minimum In-Plane Flow: [**164 gpm (621 L/min.)**] <**Insert value**> at hydraulic gradient of [**1.0**] <**Insert value**> when tested according to ASTM D 4716.

4. Filter Fabric: Comply with requirements for flat geotextile filter fabric specified in Part 2 "Geotextile Filter Fabrics" Article.

## 2.3 DRAINAGE PANELS

A. Molded-Sheet Drainage Panels: Prefabricated geocomposite, [**36 to 60 inches (915 to 1525 mm)**] <**Insert dimension**> wide with drainage core faced with geotextile filter fabric.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Drainage Core: Three-dimensional, nonbiodegradable, molded PP.

a. Minimum Compressive Strength: [**10,000 lbf/sq. ft. (479 kPa)**] [**15,000 lbf/sq. ft. (718 kPa)**] [**18,000 lbf/sq. ft. (862 kPa)**] [**21,000 lbf/sq. ft. (1005 kPa)**] <**Insert value**> when tested according to ASTM D 1621.
b. Minimum In-Plane Flow Rate: [**2.8 gpm/ft. (35 L/min. per m)**] [**7 gpm/ft. (87 L/min. per m)**] [**15 gpm/ft. (186 L/min. per m)**] <**Insert value**> of unit width at hydraulic gradient of [**1.0**] <**Insert value**> and compressive stress of [**25 psig (172 kPa)**] <**Insert value**> when tested according to ASTM D 4716.

3. 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:

a. Survivability: [**Class 1**] [**Class 2**] [**Class 3**].
b. Apparent Opening Size: [**No. 40 (0.425-mm)**] [**No. 60 (0.25-mm)**] [**No. 70 (0.212-mm)**] sieve, maximum.
c. Permittivity: [**0.5**] [**0.2**] [**0.1**] per second, minimum.

4. 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:

a. Survivability: [**Class 1**] [**Class 2**] [**Class 3**].
b. Apparent Opening Size: [**No. 40 (0.425-mm)**] [**No. 60 (0.25-mm)**] [**No. 70 (0.212-mm)**] [**No. 30 (0.6-mm)**] sieve, maximum.
c. Permittivity: [**0.5**] [**0.2**] [**0.1**] [**0.02**] per second, minimum.

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

B. Mesh Fabric Drainage Panels: Prefabricated geocomposite with drainage core faced with geotextile filter fabric.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Drainage Core: Open-construction, resilient, plastic-filament mesh, approximately 0.4 inches (10.2 mm) thick.

a. Minimum In-Plane Flow Rate: [**2.4 gpm/ft. (30 L/min. per m)**] <**Insert value**> of unit width at hydraulic gradient of [**1.0**] <**Insert value**> and normal pressure of 25 psig (172 kPa) when tested according to ASTM D 4716.

3. 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.

C. Net Fabric Drainage Panels: Prefabricated geocomposite with drainage core faced with geotextile filter fabric.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Drainage Core: Three-dimensional, PE nonwoven-strand geonet, approximately 0.25 inches (6 mm) thick.

a. Minimum In-Plane Flow Rate: [**2.4 gpm/ft. (30 L/min. per m)**] [**5 gpm/ft. (62 L/min. per m)**] <**Insert value**> of unit width at hydraulic gradient of [**1.0**] <**Insert value**> and normal pressure of 25 psig (172 kPa) when tested according to ASTM D 4716.

3. 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. Ring Fabric Drainage Panels: Drainage-core panel for field application of geotextile filter fabric.

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Drainage Core: Three-dimensional, HDPE rings-in-grid pattern, approximately 1 inch (25 mm) thick.

a. Minimum In-Plane Flow Rate: [**40 gpm/ft. (500 L/min. per m)**] <**Insert value**> of unit width at hydraulic gradient of [**1.0**] <**Insert value**> and normal pressure of 25 psig (172 kPa) when tested according to ASTM D 4716.

## 2.4 SOIL MATERIALS

A. Soil materials are specified in Section 312000 "Earth Moving."

## 2.5 WATERPROOFING FELTS

A. Material: Comply with [**ASTM D 226, Type I, asphalt**] [**or**] [**ASTM D 227, coal-tar**]-saturated organic felt.

## 2.6 GEOTEXTILE FILTER FABRICS

A. 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.

B. Structure Type: Nonwoven, needle-punched continuous filament.

1. Survivability: AASHTO [**M 288 Class 2**] <**Insert class**>.
2. Styles: Flat and sock.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine surfaces and areas for suitable conditions where subdrainage systems are to be installed.

B. If subdrainage is required for landscaping, locate and mark existing utilities, underground structures, and aboveground obstructions before beginning installation and avoid disruption and damage of services.

C. Verify that drainage panels installed as part of foundation wall waterproofing is properly positioned to drain into subdrainage system.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

## 3.2 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

## 3.3 FOUNDATION DRAINAGE INSTALLATION

A. 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.

B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.

C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).

D. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with [**adhesive**] [**or**] [**tape**].

E. Install drainage piping as indicated in Part 3 "Piping Installation" Article for foundation subdrainage.

F. 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.

G. 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.

H. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.

I. Place layer of [**flat-style geotextile filter fabric**] [**waterproofing felt**] over top of drainage course, overlapping edges at least 4 inches (100 mm).

J. Install drainage panels on foundation walls as follows:

1. Coordinate placement with other drainage materials.
2. Lay perforated drainage pipe at base of footing. Install as indicated in Part 3 "Piping Installation" Article.
3. 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.

4. Attach panels to wall beginning at subdrainage pipe. Place and secure molded-sheet drainage panels, with geotextile facing away from wall.

K. 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.

## 3.4 UNDERSLAB DRAINAGE INSTALLATION

A. 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.

B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.

C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).

D. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with [**adhesive**] [**or**] [**tape**].

E. Install drainage piping as indicated in Part 3 "Piping Installation" Article for underslab subdrainage.

F. 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.

G. 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.

H. Install horizontal drainage panels as follows:

1. Coordinate placement with other drainage materials.
2. Lay perforated drainage pipe at inside edge of footing.
3. 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.
4. Butt additional panels against other installed panels. If panels have plastic flanges, overlap installed panel with flange.

## 3.5 RETAINING-WALL DRAINAGE INSTALLATION

A. Lay flat-style geotextile filter fabric in trench and overlap trench sides.

B. Place supporting layer of drainage course over compacted subgrade to compacted depth of not less than 4 inches (100 mm).

C. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with [**adhesive**] [**or**] [**tape**].

D. Install drainage piping as indicated in Part 3 "Piping Installation" Article for retaining-wall subdrainage.

E. 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.

F. 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.

G. 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.

H. Place layer of [**flat-style geotextile filter fabric**] [**waterproofing felt**] over top of drainage course, overlapping edges at least 4 inches (100 mm).

I. Install drainage panels on wall as follows:

1. Coordinate placement with other drainage materials.
2. Lay perforated drainage pipe at base of footing as described elsewhere in this Specification. Do not install aggregate.
3. 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.
4. 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.
5. 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.
6. 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.
7. If another panel is required on same row, cut away 4 inches (100 mm) of installed panel core and wrap fabric over new panel.
8. If additional rows of panel are required, overlap lower panel with 4 inches (100 mm) of fabric.
9. Cut panel as necessary to keep top 12 inches (300 mm) below finish grade.
10. For inside corners, bend panel. For outside corners, cut core to provide 3 inches (75 mm) for overlap.

J. 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.

## 3.6 LANDSCAPING DRAINAGE INSTALLATION

A. 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.

B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.

C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).

D. Install drainage conduits as indicated in Part 3 "Piping Installation" Article 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**].

E. Add drainage course to top of drainage conduits.

F. After satisfactory testing, cover drainage conduit to within 12 inches (300 mm) of finish grade.

G. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.

H. Place layer of [**flat-style geotextile filter fabric**] [**waterproofing felt**] over top of drainage course, overlapping edges at least 4 inches (100 mm).

I. 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.

## 3.7 PIPING INSTALLATION

A. 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.

1. Foundation Subdrainage: Install piping level and with a minimum cover of [**36 inches (915 mm)**] <**Insert dimension**> unless otherwise indicated.
2. Underslab Subdrainage: Install piping level.
3. Plaza Deck Subdrainage: Install piping level.
4. 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)**] <**Insert dimension**> unless otherwise indicated.
5. Landscaping Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of [**0.5**] <**Insert value**> percent and with a minimum cover of [**36 inches (915 mm)**] <**Insert dimension**> unless otherwise indicated.
6. Lay perforated pipe with perforations down.
7. 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.

B. 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.

C. Install thermoplastic piping according to ASTM D 2321.

## 3.8 PIPE JOINT CONSTRUCTION

A. Join perforated PE pipe and fittings with couplings according to ASTM D 3212 with loose banded, coupled, or push-on joints.

B. Join perforated PVC sewer pipe and fittings according to ASTM D 3212 with loose bell-and-spigot, push-on joints.

C. 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.

## 3.9 BACKWATER VALVE INSTALLATION

A. Comply with requirements for backwater valves specified in Section 334100 "Storm Utility Drainage Piping."

B. Install horizontal backwater valves in header piping downstream from perforated subdrainage piping.

C. Install horizontal backwater valves in piping[ **in manholes or pits**] where indicated.

## 3.10 CLEANOUT INSTALLATION

A. Comply with requirements for cleanouts specified in Section 334100 "Storm Utility Drainage Piping."

B. Cleanouts for [**Foundation**] [**Retaining-Wall**] [**and**] [**Landscaping**] Subdrainage:

1. 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.
2. 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)**] <**Insert dimensions**> deep. Set top of cleanout flush with grade.
3. In nonvehicular-traffic areas, use NPS 4 (DN 100) [**cast-iron**] [**PVC**] 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)**] <**Insert dimensions**> deep. Set top of cleanout [**1 inch (25 mm)**] [**2 inches (50 mm)**] <**Insert dimension**> above grade.
4. Comply with requirements for concrete specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**]

C. Cleanouts for Underslab Subdrainage:

1. 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.

2. 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.

## 3.11 CONNECTIONS

A. Comply with requirements for piping specified in Section 334100 "Storm Utility Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect low elevations of subdrainage system to[ **building's**] solid-wall-piping storm drainage system.

C. Where required, connect low elevations of [**foundation**] [**underslab**] subdrainage to stormwater sump pumps. Comply with requirements for sump pumps specified in Section 221429 "Sump Pumps."

## 3.12 IDENTIFICATION

A. Arrange for installation of green warning tapes directly over piping. Comply with requirements for underground warning tapes specified in specified in Section 312000 "Earth Moving."

1. Install PE warning tape or detectable warning tape over ferrous piping.
2. Install detectable warning tape over nonferrous piping and over edges of underground structures.

## 3.13 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling.
2. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.

B. Drain piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

## 3.14 CLEANING

A. 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 33 46 00