EASTRIDGE TO BART REGIONAL CONNECTOR PROJECT

CAPITOL EXPRESSWAY LIGHT RAIL PROJECT

SPECIFICATIONS – 95% SUBMITTAL

VOLUME 2

Divisions 11-29

JUNE 2020

Santa Clara Valley Transportation Authority

Solutions that move you

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HYDRAULIC ELEVATORS

PART 1 – GENERAL

1.01 SUMMARY

A. Section includes three glass cab hydraulic elevators as follows:

1. Two passenger elevators, Cars 1 and 2.

2. One service elevator, Car 3.

B. Products Installed But Not Furnished Under This Section:

1. Emergency Voice/Alarm Communication System Provisions

2. Wiring provisions for car CCTV camera provisions

3. Wiring provisions for elevator related security devices, control unit, mounting brackets, wiring materials, logic circuits, security system interface terminals, boxes and relays.

4. Car interior finishes

5. Car flooring

6. Monitoring system interface

C. Related Requirements:

1. Division 01 Section “Temporary Facilities and Controls” for temporary use of elevators for construction purposes.

2. Division 03 Section “Cast-in-Place Concrete” for setting sleeves, inserts, and anchoring devices in concrete.

1.02 RELATED SECTIONS

A. Section 05 51 33, Metal Ladders

B. Section 06 16 53, Moisture-Resistant Sheathing Board

C. Section 07 16 53, Thermoplastic Sheet Waterproofing

D. Section 07 41 13, Metal Roof Panels

E. Section 07 42 13, Metal Wall Panels

F. Section 08 51 13, Aluminum Windows

G. Section 09 67 70, Elevator Spray on Flooring

1.03 DEFINITIONS

A. Terms used are defined in the latest edition of the Safety Code for Elevators and Escalators, ASME A17.1.

1.04 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Comply with ASME A17.1/CSA B44.

B. Seismic Performance: Elevator system shall withstand the effects of earthquake motions determined according to SEI/ASCE 7-16 13.3 and shall comply with elevator safety requirements for seismic risk Zone 2 or greater in ASME A17.1/CSA B44.

1. The term “withstand” means the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event.
2. Provide earthquake equipment required by ASME A17.1/CSA B44.
3. Provide seismic switch required by SEI/ASCE 7.
4. Design earthquake spectral response acceleration short period (Sds) for Project: 1.0.
5. Occupancy Category: III.
6. Project Seismic Design Category: D.
7. Elevator Component Importance Factor (Ip): 1.25.

1.05 SUBMITTALS

A. Product Data: Include capacities, sizes, performances, operations, safety features, finishes, and similar information. Include product data for car enclosures, hoistway entrances, and operation, control, and signal systems. Include product data for signal fixtures, lights, graphics, Braille plates, and details of mounting provisions.

B. Shop Drawings:

1. Include plans, elevations, sections, and large-scale details indicating openings at each landing, machine room layout, coordination with building structure, relationships with other construction, and locations of equipment.

2. Include large-scale layout of car operating panel and standby power operation control panel.

3. Indicate maximum dynamic and static loads imposed on building structure at points of support and maximum and average power demands.

4. Power Confirmation Information: Include motor horsepower, code letter, starting current, full-load running current, and demand factor. Provide maximum and average power consumption.

C. Samples for Initial Selection: For finishes involving surface treatment, paint or color selection.

D. Samples for Verification: For exposed car, hoistway door and frame, and signal equipment finishes:

1. Samples of sheet materials: 3" square.

2. Running trim members: 4" lengths.

E. Operation and Maintenance Data:

1. For elevators to include in emergency, operation, and maintenance manuals.

2. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include diagnostic and repair information available to manufacturer's and Installer's maintenance personnel.

F. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted elevator use.

G. Continuing Maintenance Proposal: Submit a continuing maintenance proposal from Installer to Owner, in the form of a standard five-year maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

1.06 QUALITY ASSURANCE

A. Compliance with Regulatory Agencies: Comply with most stringent applicable provisions of following codes, laws, and/or authorities, including revisions and changes in effect:

1. Safety Code for Elevators and Escalators, ASME A17.1

2. Guide for Inspection of Elevators, Escalators, and Moving Walks, ASME A17.2

3. Elevator and Escalator Electrical Equipment, ASME A17.5

4. National Electrical Code, NFPA 70

5. Americans with Disabilities Act, ADA

6. Uniform Federal Accessibility Standard, UFAS

7. Local Fire Authority

8. Requirements of most stringent provision of local applicable building code within the governing jurisdiction.

9. Life Safety Code, NFPA 101.

10. California Accessibility Standards, Title 24 Chapter 11b.

11. California Code of Regulations Title 8 and California Building Code Title 24

1.07 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver material in Contractor's original unopened protective packaging.

B. Store material in original protective packaging. Prevent soiling, physical damage, or moisture damage.

C. Protect equipment and exposed finishes from damage and stains during transportation and construction.

1.08 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair, restore, or replace elevator work that fails in materials or workmanship within specified warranty period.

B. Failures include, but are not limited to: operation or control system failure, including excessive malfunctions; performances below specified ratings; excessive wear; unusual deterioration or aging of materials or finishes; unsafe conditions; need for excessive maintenance; abnormal noise or vibration; and similar unusual, unexpected, and unsatisfactory conditions.

C. Warranty Period: One year from date of Substantial Completion.

1.09 MAINTENANCE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include twelve months full maintenance by competent and licensed employees of elevator Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper elevator operation at rated speed and capacity. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

1. Perform maintenance during normal working hours.

2. Perform emergency callback service during normal working hours. Include 24-hour-per-day, 7-day-per-week emergency callback service with response time of ninety minutes or less.

1.10 MEASUREMENT AND PAYMENT

A. Measurement: Hydraulic Elevators shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Hydraulic Elevators shall include full compensation for the various contract items of work described in this section and no additional compensation will be allowed therefore.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include the following:

1. KONE Inc.
2. Minnesota Elevator, Inc.
3. Mitsubishi Electric Corporation.
4. Otis Elevator Co.
5. Schindler Elevator Corp.
6. thyssenkrupp Elevator.

2.02 ELEVATORS

A. Elevator System, General: Manufacturer's standard elevator systems. Unless otherwise indicated, manufacturer's standard components shall be used, as included in standard elevator systems and as required for complete system.

B. Two Passenger Elevators Description:

ELEVATORS 1 AND 2

1. Capacity: 3,500 lbs.
2. Class of Loading: Passenger Class A
3. Contract Speed: 125 fpm

ELEVATORS 1 AND 2

4. Machine: Hydraulic Pump

5. Machine Location: Remote at bottom landing

6. Operational Control: Selective collective

7. Motor Control: Single speed AC with electronic soft start

8. Power Characteristics: 480 Volts, 3 Phase, 60 Hertz

9. Stops and Openings: 2, both front

10. Floors Served: L, 3

11. Travel: 17'-0" ±

12. Platform Size: 7'-0" wide x 6'-2" deep

13. Minimum Clear Inside Car: 6'-8" wide x 5'-5" deep x 8'-0" high

14. Entrance Size: 3'-6" wide x 7'-0" high

15. Entrance Type: Single-speed side-opening

16. Door Operator: Medium-speed heavy-duty with 1.5 fps minimum opening speed.

17. Door Protection: Infrared full screen device with differential timing, nudging, and interrupted beam time

18. Hydraulic Type: Direct plunger

19. Guide Rails: Planed steel tees

20. Buffers: Spring

21. Car Enclosure:
    a. As specified on architectural drawings.
    b. Battery powered emergency car lighting. Provide separate constant-pressure test button in car service compartment.
    c. Car interior air conditioning

22. Signal Fixtures: LED illumination. Contractor's standard design, vandal resistant assembly.
    a. Hall and Car Pushbutton Stations:

1) Single hall pushbutton riser.

2) Single car operating panel.

3) Vandal resistant car and hall pushbuttons.

b. Car Position Indicators: Digital with car direction arrows.

c. Hall Lanterns: At all floors with volume adjustable electronic chime or tone. sound twice for down direction, vandal resistant assembly.

d. Submittal Fixture: Submit brochure depicting Contractor's proposed designs with bid.

23. Communication System: Self-dialing, vandal resistant, push to call, two-way communication system with recall, tracking, and voiceless communication

24. Additional Features:

a. Car roller guides

b. Car top inspection station

c. Firefighters' Service, Phases I and II, including alternate floor return

d. Hoistway access switches, top and bottom floors

e. Hoistway door unlocking device at all floors

f. Battery pack standby power provision

g. Accessibility signage

h. Swing car return panels arranged for integral car operating panels

i. Platform isolation, jack to platen connections

j. Independent service feature

k. Individual floor lockoff feature for ground floor

l. Card reader provisions, all cars

m. CCTV provisions, all cars

n. Hydraulic pump unit and controller sound isolation

o. Tamper-resistant fasteners for all fastenings exposed to the public

p. One-year warranty maintenance with 24-hour callback service

q. Seismic safety valve

r. Jack hole, outer casing, and watertight PVC inner casing with secondary containment provisions

s. Watertight PVC sleeve for underground piping with secondary containment provisions

ELEVATORS 1 AND 2

t. Signage engraving filled with black paint or approved etching process

u. No visible company name or logo

v. Wiring diagrams, operating instructions, and parts ordering information

C. One Service Elevator Description:

ELEVATOR 3

1. Capacity: 4,000 lbs.
2. Class of Loading: Service Class CA
3. Contract Speed: 125 fpm
4. Machine: Hydraulic Pump
5. Machine Location: Remote at bottom landing
6. Operational Control: Selective collective
7. Motor Control: Single speed AC with electronic soft start
8. Power Characteristics: 480 Volts, 3 Phase, 60 Hertz
9. Stops and Openings: 2 front; 1 rear
10. Floors Served: Front: L2, 3; Rear: 3
11. Travel: 17'-0" ±
12. Platform Size: 6'-0" wide x 8'-4" deep
13. Minimum Clear Inside Car: 5'-8" wide x 7'-5" deep x 8'-0" high
14. Entrance Size: 4'-0" wide x 7'-0" high
15. Entrance Type: Two-speed side-opening
16. Door Operator: Medium-speed heavy-duty with 1.5 fps minimum opening speed.
17. Door Protection: Infrared full screen device with differential timing, nudging, and interrupted beam time
18. Hydraulic Type: Direct plunger

ELEVATOR 3

19. Guide Rails: Planed steel tees

20. Buffers: Spring

21. Car Enclosure:

    a. As specified on architectural drawings.

    b. Battery powered emergency car lighting. Provide separate constant-pressure test button in car service compartment.

    c. Car interior air conditioning

22. Signal Fixtures: LED illumination. Contractor's standard design, vandal resistant assembly.

    a. Hall and Car Pushbutton Stations:

        1) Single hall pushbutton riser.

        2) Single car operating panel.

        3) Vandal resistant car and hall pushbuttons.

    b. Car Position Indicators: Digital with car direction arrows.

    c. Hall Lanterns: At all floors with volume adjustable electronic chime or tone. sound twice for down direction, vandal resistant assembly.

    d. Submittal Fixture: Submit brochure depicting Contractor's proposed designs with bid.

23. Communication System: Self-dialing, vandal resistant, push to call, two-way communication system with recall, tracking, and voiceless communication

24. Additional Features:

    a. Car roller guides

    b. Car top inspection station

    c. Firefighters' Service, Phases I and II, including alternate floor return

    d. Hoistway access switches, top and bottom floors

    e. Hoistway door unlocking device at all floors

    f. Battery pack standby power provision

    g. Accessibility signage

    h. Swing car return panels arranged for integral car operating panels

    i. Platform isolation, jack to platen connections

    j. Independent service feature

ELEVATOR 3

k. Individual floor lockoff feature for ground floor

l. Card reader provisions, all cars

m. CCTV provisions, all cars

n. Hydraulic pump unit and controller sound isolation

o. Tamper-resistant fasteners for all fastenings exposed to the public

p. One-year warranty maintenance with 24-hour callback service

q. Seismic safety valve

r. Jack hole, outer casing, and watertight PVC inner casing with secondary containment provisions

s. Watertight PVC sleeve for underground piping with secondary containment provisions

t. Signage engraving filled with black paint or approved etching process

u. No visible company name or logo

v. Wiring diagrams, operating instructions, and parts ordering information

2.03 MATERIALS

A. Steel:

1. Sheet Steel (Furniture Steel for Exposed Work): Stretcher-leveled, cold-rolled, commercial quality carbon steel, complying with ASTM A366, matte finish.

2. Sheet Steel (for Unexposed Work): Hot-rolled, commercial quality carbon steel, pickled and oiled, complying with ASTM A568/A568M-03.

3. Structural Steel Shapes and Plates: ASTM A36.

B. Stainless Steel: Type 302 or 304 complying with ASTM A240, with standard tempers and hardness required for fabrication, strength, and durability. Apply mechanical finish on fabricated work in the locations shown or specified, Federal Standard and NAAMM nomenclature, with texture and reflectivity required to match Architect’s sample. Protect with adhesive paper covering.

1. No. 4 Satin: Directional polish finish. Graining directions as shown or, if not shown, in longest dimension.

2. No. 8 Mirror: Reflective polish finish with no visible graining.

3. Textured: Provide 5WL as manufactured by Rigidized Metals or Windsor pattern 5-SM as manufactured by Rimex Metals or approved equal with .050 inches mean pattern depth with bright directional polish (No. 4 satin finish).

4. Burnished: Non-directional, random abrasion pattern.

5. Acid-Etched Pattern: Provide a No. 8 mirror reflective-polished background with selectively acid-etched, matte-textured, custom pattern as shown. Acid selection and Aluminum: Extrusions per ASTM B221; sheet and plate per ASTM B209.

C. Plastic Laminate: ASTM E84 Class A and NEMA LD3.1, Fire-Rated Grade (GP-50), Type 7, 0.050" ±.005" thick, color and texture as follows:

1. Exposed Surfaces: Color and texture selected by Architect.

2. Concealed Surfaces: Contractor’s standard color and finish.

D. Fire-Retardant Treated Particle Board Panels: Minimum 3/4" thick backup for natural finished wood and plastic laminate veneered panels, edged and faced as shown, provided with suitable anti-warp backing; meet ASTM E84 Class “I” rating with a flame-spread rating of 25 or less, registered with Local Authorities for elevator finish materials.

E. Natural Finish Wood Veneer: Standard thickness, 1/40" thoroughly dried conforming to ASME/HPMA HP-1983, Premium Grade. Place veneer, tapeless spliced with grain running in direction shown, belt, and polish sanded, book-matched. Species and finish designated and approved by Architect.

F. Paint: Clean exposed metal parts and assemblies of oil, grease, scale, and other foreign matter and factory paint one shop coat of standard rust-resistant primer. After erection, provide one finish coat of industrial enamel paint. Galvanized metal need not be painted.

G. Prime Finish: Clean all metal surfaces receiving a baked enamel paint finish of oil, grease, and scale. Apply one coat of rust-resistant primer followed by a filler coat over uneven surfaces. Sand smooth and apply final coat of primer.

H. Baked Enamel Finish: Prime finish per above. Unless specified “prime finish” only, apply and bake three additional coats of enamel in the selected solid color.

I. Stone: Refer to Section ...., Stone.

J. Carpet: Refer to Section ...., Carpet.

K. Vinyl tile: Refer to Section ...., Vinyl Composition Tile.

L. Glass: Laminated safety glass, minimum 9/16" thick, conforming to ANSI Z97.1 and CPSC 16 CFR Part 1201.

2.04 CAR PERFORMANCE

A. Car Speed: ±10% of contract speed under any loading condition.

B. Car Capacity: Safely lower, stop and hold 125% of rated load.

C. Car Stopping Zone: ±1/4" under any loading condition.

D. Door Times: Seconds from start to fully open or fully closed.

1. Elevators 1 and 2:
   a. Door Open: 3.1 seconds.
   b. Door Close: 4.0 seconds.

2. Elevator 3:
   a. Door Open: 3.5 seconds.
   b. Door Close: 4.6 seconds.

E. Car Floor-to-Floor Performance Time: Seconds from start of doors closing until doors are 1/2 open, and car is level and stopped at next successive floor under any loading condition or travel direction (17'-0" typical floor height).

1. Elevator 1 and 2: 18.0 seconds.

2. Elevator 3: 19.0 seconds.

F. Pressure: Fluid system components shall be designed and factory tested for 500 psi. Maximum operating pressure shall be 400 psi.

G. Noise and Vibration Control

1. Airborne Noise: Measured noise level of elevator equipment and its operation shall not exceed 60 dBA inside car under any condition including door operation and car ventilation exhaust blower on its highest speed. Limit noise level in the machine room relating to elevator equipment and its operation to no more than 80 dBA. All dBA readings to be taken 3'-0" off the floor and 3'-0" from the equipment using the "A" weighted scale.

2. Vibration Control: All elevator equipment provided under this contract, including power unit, controller, oil supply lines, and their support shall be mechanically isolated from the building structure and electrically isolated from the building power supply and to each other to minimize the possibility of objectionable noise and vibrations being transmitted to occupied areas of the building.

2.05 OPERATION

A. Collective Microprocessor-Based:

1. Operate car without attendant from pushbuttons in car and located at each floor. When car is available, automatically start car and dispatch it to floor corresponding to registered car or hall call. Once car starts, respond to registered calls in direction of travel and in the order the floors are reached.

2. Do not reverse car direction until all car calls have been answered, or until all hall calls ahead of car and corresponding to the direction of car travel have been answered.

3. Slow car and stop automatically at floors corresponding to registered calls, in the order in which they are approached in either direction of travel. As slowdown is initiated for a hall call, automatically cancel hall call. Cancel car calls in the same manner. Hold car at arrival floor an adjustable time interval to allow passenger transfer.

4. Answer calls corresponding to direction in which car is traveling unless call in the opposite direction is highest (or lowest) call registered.

5. Illuminate appropriate pushbutton to indicate call registration. Extinguish light when call is answered.

B. Other Items:

1. Low Oil Control: In the event oil level is insufficient for travel to the top floor, provide controls to return elevator to the main level and park until oil is added.

2. Load Weighing: Provide means for weighing car passenger load. Control system to provide dispatching at main floor in advance of normal intervals when car fills to capacity. Provide hall call by-pass when the car is filled to preset percentage of rated capacity and traveling in down direction. Field adjustment range: 10% to 100%.

3. Anti-Nuisance Feature: If car loading relative to weight in car is not commensurate with number of registered car calls, or activation of door protection device is not commensurate with number of registered car calls, cancel car calls.

4. Independent Service: Provide controls for operation of each car from its pushbuttons only. Close doors by constant pressure on desired destination floor button or door close button. Open doors automatically upon arrival at selected floor.

C. Car-to-Lobby Feature: Provide the means in the main hall pushbutton station for automatic return to the lobby floor. Return car nonstop after answering pre-registered car calls, and park with doors open for an adjustable time period of 60-90 seconds. Upon expiration of time period, car shall automatically revert to normal operation and close its doors until assigned as next car or until the car is placed on manual control via in-car attendant or out-of-service switch.

D. Firefighters' Service: Provide equipment and operation in accordance with code requirements.

E. Automatic Car Stopping Zone: Stop car within 1/4" above or below the landing sill. Maintain stopping zone regardless of load in car, direction of travel, distance between landings.

F. Motion Control: Microprocessor-based AC type with unit valve suitable for operation specified and capable of providing smooth, comfortable car acceleration and retardation. Limit the difference in car speed between full load and no load to not more than ±10% of the contract speed in either direction of travel.

G. Door Operation: Automatically open doors when car arrives at main floor. At expiration of normal dwell time, close doors. Provide “heavy door/variable air pressure” feature for consistent specified door operation within appropriate speed and inertia limits.

H. Standby Lighting and Alarm: Car mounted battery unit with solid-state charger to operate alarm bell and car emergency lighting. Battery to be rechargeable with minimum five-year life expectancy. Include required transformer. Provide constant pressure test button in service compartment of car operating panel. Provide lighting integral with portion of normal car lighting system.

I. Battery Lowering Feature: Upon loss of normal power, provide controls to automatically lower the car(s) to the nearest lower landing. Upon arrival at the lowest landing, the elevator doors shall open automatically and remain open until regular door time has expired. The elevator shall then become deactivated. The standby power source shall be provided via 12-volt D.C. battery units installed in machine room, including solid-state charger and testing means mounted in a common metal container. Battery to be rechargeable lead acid or nickel cadmium with a ten-year life expectancy. Upon restoration of normal power, the elevator shall automatically resume normal operation.

J. Battery Standby Power Pack for Air Conditioner/Heater: Upon loss of normal power, standby power source shall be provided via 12-volt D. C. battery units installed in machine room, including solid-state charger and testing means mounted in a common metal container. Battery to be rechargeable lead acid or nickel cadmium with a ten-year life expectancy. Standby power source shall provide minimum four hours operation.

K. Card/Proximity Reader Security System: Provide provisions inside all elevators for reader unit. Mount reader unit as directed by Architect and cross connect from car pushbuttons to control module in machine room. Reader control unit, mounting brackets, wiring materials, logic circuits, etc., by Security Subcontractor. Provide a filler plate to match card slot size and car return panel finish, including direction of graining, where card slot or proximity reader cutout is not initially utilized. Elevator control systems shall facilitate system tracking of persons accessing secure floors via printout by passenger I.D. number, floor accessed, and time of entry.

2.06 MACHINE ROOM EQUIPMENT

A. Arrange equipment in spaces shown on drawings.

B. Pump Unit:

1. Assembled unit consisting of positive displacement pump, induction motor, master-type control valves combining safety features, holding, direction, bypass, stopping, manual lowering functions, shut off valve, oil reservoir with protected vent opening, oil level gauge, outlet strainer, drip pan, muffler, all mounted on isolating pads.

2. Provide oil thermal unit, oil cooling unit and oil temperature thermostat to maintain oil at operating temperature.

3. Enclose entire unit with removable sheet steel panels lined with sound-absorbing material.

4. Design unit for 120 up starts/hour.

C. Landing System: Solid-state, magnetic, or optical type.

D. Controller: UL/CSA labeled. MCE 2000 controls:

1. Compartment: Securely mount all assemblies, power supplies, chassis switches, relays, etc., on a substantial, self-supporting steel frame. Completely enclose equipment with covers. Provide means to prevent overheating.

2. Relay Design: Magnet operated with contacts of design and material to insure maximum conductivity, long life, and reliable operation without overheating or excessive wear. Provide wiping action and means to prevent sticking due to fusion. Contacts carrying high inductive currents shall be provided with arc deflectors or suppressors.

3. Microprocessor-Related Hardware:

    a. Provide built-in noise suppression devices which provide a high level of noise immunity on all solid-state hardware and devices.

    b. Provide power supplies with noise suppression devices.

    c. Isolate inputs from external devices (such as pushbuttons) with opto-isolation modules.

    d. Design control circuits with one leg of power supply grounded.

    e. Safety circuits shall not be affected by accidental grounding of any part of the system.

    f. System shall automatically restart when power is restored.

    g. System memory shall be retained in the event of power failure or disturbance.

    h. Equipment shall be provided with Electro Magnetic Interference (EMI) shielding within FCC guidelines.

4. Wiring: CSA labeled copper for factory wiring. Neatly route all wiring interconnections and securely attach wiring connections to studs or terminals.

5. Permanently mark components (relays, fuses, PC boards, etc.) with symbols shown on wiring diagrams.

6. Monitoring System Interface: Provide controller with serial data link through RJ45 Ethernet connection and install all devices necessary to monitor items outlined in Section 2.13. Elevator contractor responsible to connect monitoring system interface

to machine room monitoring compartment and LAN. Wiring from the LAN to the machine room monitoring compartment by others.

7. Provide controller or machine mounted auxiliary lockable "open" disconnect if mainline disconnect is not in sight of controller and/or machine.

E. Muffler: Provide in discharge oil line near pump unit. Design shall dampen and absorb pulsation and noise in the flow of hydraulic fluid.

F. Piping and Oil: Provide piping, connections and oil for the system. Buried piping shall be secondarily contained with watertight Schedule 40 PVC sleeves between elevator machine room and pit. A minimum of two sound isolation couplings shall be provided between the pump unit and oil line and the oil line and jack unit. Provide isolated pipe stands or hangers as required.

G. Shut-Off Valve: manual valve on line adjacent to pump unit. Provide second valve in pit adjacent to jack unit.

2.07 HOISTWAY EQUIPMENT

A. Guide Rails: Planed steel T-sections for car of suitable size and weight for the application, including seismic reactions, including brackets for attachment to building structure. Provide rail backing to meet code requirements. Provide bracketing, at top and bottom of floor beams. No additional structural points of rail attachment, other than those shown on the Contract Documents, will be provided.

B. Buffers: Spring type with blocking and support channels.

C. Hydraulic Jack Assembly:

1. Cylinders: Seamless steel pipe. Design head to receive unit-type packing and provide means to collect oil at cylinder head and return automatically to oil reservoir. Provide secondary containment/cylinder protection. Provide cylinder stabilizer bracketing between guide rails as required.

2. Plungers: Polished seamless steel tubing or pipe. If plunger length exceeds 24'-0", provide two or more sections not exceeding 16'-0" in length, or coordinate installation of longer unit at the jobsite. Join sections by internal threaded couplings. Multiple section jack units shall be factory polished while assembled and marked for proper future reassembly. Isolate plunger from car frames.

D. Sheaves: Machined grooves and sealed bearings. Provide mounting means to top of plungers.

E. Jack Support and Fluid Shut-Off Valves: Provide steel pit channels to support jack assembly and transmit loads to building structure. Provide intermediate stabilizers as required. Provide manual on/off valves in oil lines adjacent to pump unit and jack units in pit.

F. Well Hole Casing:

1. Well hole is to be provided by Elevator Contractor. No additional compensation will be allowed for unforeseen conditions of any kind or spoil removal.

2. Install steel outer casing minimum 18" diameter. Install watertight sleeve over jack assembly for secondary containment prior to insertion into the outer casing. Extend PVC sleeve through pit floor slab to underside of jack support beams and seal with non-permeable membrane. Seal well opening at the pit floor with hydraulic quick setting cement. Provide PVC vision/access ports. Seal well opening at the pit floor with hydraulic quick setting cement. Provide PVC vision/access ports. I.D. of PVC sleeve shall be capable of containing 110% of system fluid capacity.

G. Overspeed Valves: Provide a pressure sensitive, mechanically-actuated seismic safety valve, conforming to ASME A17.1, Rule 3.19.4.7. Connect valve directly to jack assembly inlet.

H. Terminal Stopping: Provide normal and final devices.

I. Electrical Wiring and Wiring Connections:

1. Conductors and Connections: Copper throughout with individual wires coded and connections on identified studs or terminal blocks. Use no splices or similar connections in wiring except at terminal blocks, control compartments, or junction boxes. Provide 10% spare conductors throughout. Run spare wires from car connection points to individual elevator controllers in the machine room.

2. Conduit: Galvanized steel conduit, EMT, or duct. Flexible conduit length not to exceed 3'-0". Flexible heavy-duty service cord may be used between fixed car wiring and car door switches for door protective devices. Conduit from the closest hoistway of each elevator to the firefighters' control room console.

3. Traveling Cables: Flame and moisture-resistant outer cover. Prevent traveling cable from rubbing or chafing against hoistway or equipment within hoistway.
   a. Provide five pair of shielded wires of minimum 18 gauge for card reader.
   b. Provide one RG-6/U coaxial CCTV cable and two pair of shielded 18 gauge wire within traveling cable from car controller to car top junction box, plus 3'-0" excess loop at both ends.
   c. Provide two pair of 18 gauge wire for CCTV power.
   d. Provide eight pair of spare shielded communication wires in addition to those required to connect specified items.
   e. Tag spares in machine room. Provide cables from controller to car top.

4. Auxiliary Wiring: Provide conduit, wiring and connections for fire alarm initiating devices, emergency two-way communication system, firefighters' phone jack, paging speaker, CCTV, security system and card reader interface terminals and relays,

intercom, and announcement speaker and/or background music from the machine room junction box to each car controller in machine room.

J. Entrance Equipment:

1. Door Hangers: Two-point hanger roller with neoprene roller surface and suspension with eccentric upthrust roller adjustment.

2. Door Tracks: Bar or formed, cold-drawn removable steel tracks with smooth roller contact surface.

3. Door Interlocks: Operable without retiring cam. Paint interlock box flat black.

4. Door Closers: Spring, spirator, or jamb/strut mounted counterweight type. Design and adjust to insure smooth, quiet mechanical close of doors.

5. Hoistway Door Unlocking Device: Provide unlocking device with escutcheon in door panel at all floors, with finish to match adjacent surface.

6. Hoistway Access Switches: Mount in entrance frame side jamb at top and bottom floors. Provide switch with faceplate.

K. Floor Numbers: Stencil paint 4" high floor designations in contrasting color on inside face of hoistway doors or hoistway fascia in location visible from within car.

2.08 HOISTWAY ENTRANCES

A. Complete entrances bearing fire labels from a nationally recognized testing laboratory approved within the governing jurisdiction.

B. Frames: 14 gauge hollow metal at all floors. Bolted and lapped head to jamb assembly at all floors. Clad frames with finish material indicated in finish schedule at all floors. Provide Arabic floor designation/Braille plates, centered at 60" above finished floor, on both side jambs of all entrances. Provide plates at main egress landing with “Star” designation. For designated emergency car, provide “Star of Life” designation plates at height of 78"-84" above finished floor on both side jambs at all floors. Braille indications shall be below Arabic floor designation. Provide cast floor designation/Braille plates as manufactured by SCS, Vision Mark, or Entrada. Size clear opening of subframes at least 4" wider and 2" higher than clear finish opening.

C. Door Panels: 14 gauge steel, sandwich construction without binder angles. Door opening and closing shall conform to ASME A17.1 requirement. Vision panels, two six-inch by 48-inch with one-inch stainless steel muntin between panels, on the slow speed door. Panels front and rear framing, operating levers, and integral hardware shall by type 304 stainless steel: panel shall have No. 4 finish. Window glass shall be 9/16 inch thick, clear laminated type conforming to ANSI Z97.1. Each door panel shall have a minimum of three door guides (gibs), two standard gibs and one metal Z bracket located between the other gibs.

D. Sight Guards: 14 gauge, same material and finish as hoistway entrance door panels. Construct without sharp edges.

E. Sills: Stainless steel.

F. Sill Supports:

1. Structural or formed steel designed to support door sill based upon car loading classification.

2. Mount to eliminate need for grout under the sill.

3. Provide 5" x 5" x 1/2" structural steel angle, extending full width of hoistway. Fasten to building structure at maximum 18" O.C.

G. Fascia, Toe Guards and Hanger Covers: 14 gauge furniture steel with black enamel finish.

H. Struts and Headers: Provide for vertical support of entrances and related material. Provide door open bumpers on entrances equipped with vertical struts.

I. Finish of Frames and Doors: Satin finish stainless steel.

J. Hoistway Access Switches: Mount in entrance frame side jamb at top and bottom floors. Provide switch with faceplate.

2.09 CAR EQUIPMENT

A. Frame: Welded or bolted, rolled or formed steel channel construction to meet load classification specified.

B. Platform: Isolated type, constructed of steel, or steel and wood which is fireproofed on underside. Design and construct to accommodate load classification requirements. Provide Class “A” construction for passenger elevators and Class ‘’A’’ construction for service elevator. Provide recess to accommodate floor thickness.

C. Platform Apron:

1. Elevators 1 and 2: Minimum 14 gauge steel, reinforced and braced to car platform with Contractor’s standard finish.

2. Elevator 3: Minimum 14 gauge steel, reinforced and braced to car platform front and rear with Contractor’s standard finish.

D. Guide Shoes: Roller type with three or more spring dampened, sound-deadening rollers per shoe. Maximum roller rotation speed, 350 rpm.

E. Finish Floor Covering: Furnished under other sections.

F. Sills: One piece extrusion with extruded stainless steel extension between car entrance columns to face of car front return. Extruded extension to match finish of sill.

G. Door Panels: 16 gauge type 304 stainless steel with #4 finish, on all exterior surfaces, with type 304 stainless steel “hat” type or “Z” bar reinforcement on seven-inch centers. Grain of stainless steel shall be oriented parallel to longest dimension. Doors shall have a clear opening of 42 inches by 84 inches. Include two six-inch wide by 48-inch high vision panels with a one-inch stainless steel muntin between vision panels in the slow speed doors. Glass shall be 9/16 inch clear laminated and conform to ASSI Z97.1. Each door panel shall have a minimum of three door guides(gibs), two standard gibs and one metal Z bracket located between the other gibs.

H. Door Hangers: Two-point hanger roller with neoprene roller surface and suspension with eccentric upthrust roller adjustment.

I. Door Track: Bar or formed, cold-drawn removable steel track with smooth roller contact surface.

J. Door Header: Construct of minimum 12 gauge steel, shape to provide stiffening flanges.

K. Door Electrical Contact: Prohibit car operation unless car door is closed.

L. Door Clutch: Heavy-duty clutch, linkage arms, drive blocks and pickup rollers or cams to provide positive, smooth, quiet door operation. Design clutch so car doors can be closed, while hoistway doors remain open.

M. Restricted Opening Device: Provide car-door interlock to prevent opening of car doors outside unlocking zone.

N. Door Operator: Medium-speed, heavy-duty door operator capable of opening doors at no less than 1½ fps. Accomplish reversal in no more than 2½" of door movement. Provide solid-state door control with closed loop circuitry to constantly monitor and automatically adjust door operation based upon velocity, position, and motor current. Provide a minimum of four controller-activated motion profiles, per floor, per door, to maintain consistent, smooth, and quiet door operation at all floors, regardless of door weight or varying air pressure.

O. Door Control Device:

1. Infrared Reopening Device:

   a. Black, fully enclosed device with full screen infrared matrix or multiple beams extending vertically along leading edge of each door panel to minimum height of 7'-0" above finished floor. Provide additional beams full height of door panels. Device shall prevent doors from closing and reverse doors at normal opening speed if beams are obstructed while doors are closing, except during nudging operation. In event of device failure, provide for automatic shutdown of car at floor level with doors open.

b. Acceptable Infrared Reopening Device:

1) Cegard/MAX-154 by CEDES

2) Gatekeeper by Adams

3) Lambda II by Otis

4) Magic Edge by Tri-Tronics

5) Microlite by thyssenkrupp

6) Microscan E by T.L. Jones

7) Pana40 Plus by Janus

2. Nudging Operation: After beams of door control device are obstructed for a predetermined time interval (minimum 20.0-25.0 seconds), warning signal shall sound and doors shall attempt to close with a maximum of 2.5 foot pounds kinetic energy. Activation of the door open button shall override nudging operation and reopen doors.

3. Interrupted Beam Time: When beams are interrupted during initial door opening, hold door open a minimum of 3.0 seconds. When beams are interrupted after the initial 3.0 second hold open time, reduce time doors remain open to an adjustable time of approximately 1.0-1.5 seconds after beams are reestablished.

4. Differential Door Time: Provide separately adjustable timers to vary time that doors remain open after stopping in response to calls.

a. Car Call: Hold open time adjustable between 3.0 and 5.0 seconds.

b. Hall Call: Hold open time adjustable between 5.0 and 8.0 seconds. Use hall call time when car responds to coincidental calls.

P. Car Operating Panel:

1. Elevators 1-2: One car operating panel without faceplate consisting of a metal box containing the operating fixtures, mounted behind the car swing front return panel.

2. Elevator 3: Two car operating panels without faceplate consisting of a metal box containing the operating fixtures, mounted behind the car swing front return panel.

a. Provide manually operated stop switch within Firefighters' Phase II compartment.

b. Provide "door open" button to stop and reopen doors or hold doors in open position.

c. Provide "door close" button to activate door close cycle. Cycle shall not begin until normal door dwell time for a car or hall call has expired, except firefighters' operation.

d. Locked panel including Phase II fire access switch and hidden floor buttons, call cancel button, door open, door close, switch, stop switch, light jewel, within locked panel, for fire officer use and use of car on independent service only.

3. Suitably identify floor buttons, alarm button, door open button, door close button, and emergency push-to-call button with SCS, Entrada, or equal cast tactile symbols surface mounted fastenings. Configure plates per local building code accessibility standards including Braille. Locate top floor button at maximum height allowed above the car floor; no lower than 35" for emergency push-to-call button and alarm button.

4. Provide minimum 3/4" diameter raised floor pushbuttons that illuminate to indicate call registration.

5. Provide alarm button to ring bell located on car. Illuminate button when actuated.

6. Provide Firefighters’ devices and operation.

7. Provide earthquake indicator light jewel and audible signal.

8. Provide lockable service compartment with recessed flush door. Door material and finish shall match car return panel or car operating panel faceplate. Inside surface of door shall contain an integral flush window for displaying the elevator operating permit. Include the following controls in lockable service cabinet with function and operating positions identified by permanent signage or engraved legend:

   a. Inspection switch.
   b. Light switch.
   c. Three-position exhaust blower switch
   d. Independent service switch.
   e. Constant pressure test button for battery pack emergency lighting.
   f. 120-volt, AC, GFCI protected electrical convenience duplex outlet.
   g. Card reader override switch.
   h. Switch to select either floor voice annunciation, floor passing tone, or chime.
   i. Keyed stop switch.

9. Provide black paint filled (except as noted), engraved, or approved etched signage as follows with approved size and font:

   a. Phase II firefighters’ operating instructions on inside face of firefighters’ compartment door. Engrave filled red firefighters’ operation on outside face of compartment door.
   b. Building identification car number on main car operating panel.
   c. Car capacity in pounds on service compartment door.

d. Loading classification and description on service compartment door.

Q. Car Top Control Station: Mount to provide safe access and utilization while standing in an upright position on car top.

R. Work Light and Duplex Plug Receptacle: GFCI protected outlet at top and bottom of car. Include on/off switch and lamp guard. Provide additional GFCI protected outlet on car top for installation of car CCTV.

S. Communication System:

1. Two-way communication instrument in car with automatic dialing, tracking, and recall features, with shielded wiring to car controller in machine room. Provide dialer with automatic rollover capability with minimum two numbers.
   a. Actuate two-way communication via “Help” button.
   b. Button or adjacent light jewel shall illuminate and flash when call is acknowledged.
   c. Button shall match car operating panel pushbutton design.
   d. Provide “Help” button tactile symbol, engraved signage, and Braille adjacent to button mounted integral with car front return panel.

2. Firefighters’ communication jack in car and firefighters’ panel. Jack bezel shall match adjacent controls.

3. Install remote speakers provided in car behind front return panel with drilled speaker pattern, with shielded wiring to machine room junction box.

4. Provide two-way communication between car and machine room if required.

2.10 CAR ENCLOSURE

A. Elevators 1-3: Provide complete as specified herein and detailed on architectural drawings.

1. Shell: Reinforced 14-gauge furniture steel formed panels with baked enamel interior finish as selected. Apply sound-deadening mastic to exterior. Provide concealed ventilation cutouts.

2. Canopy: Reinforced 14-gauge furniture steel formed panels with lockable, contacted, hinged emergency exit. Interior finish white color reflective baked enamel.

3. Front Return Panels and Integral Entrance Columns: Reinforced 14 gauge furniture steel clad with minimum 16 gauge satin finish stainless steel. Swing entire unit on substantial pivot points (minimum three) for service access to car operating panels. Locate pivot points to provide full swing of front return panel without interference with side wall finish or handrail. Secure in closed position with concealed three-point latch. Provide firefighters’ and service compartments with recessed flush cover and cutouts for operating switches, etc.

4. Elevator car interior back and side walls9/16 inch thick HS laminated safety glass panels, meeting the requirements of ANSI Z97.1, consisting of two layers of ¼ inch clear HS plate (float) glass with 0.060 inch polyvinyl butyral plastic interlayer, in accordance with Glazing Section. All glass panels shall be permanently marked indication compliance with ANSI Z97.1. Type 304 stainless steel framing member, as indicated on Architectural drawings. Glazing shall be removable and replaceable from inside of elevator cab. Provide slots for ventilation, as indicated on Architectural drawings.

5. Transom: Reinforced 14 gauge furniture steel clad with minimum 16 gauge satin finish stainless steel full width of enclosure.

6. Base: Satin finish stainless steel.

7. Interior Wall Finish: per Architectural plans and drawings.

8. Ventilation: Morrison Products, Inc. three-speed model SOE 06-01055 exhaust blower mounted to car canopy on isolated rubber grommets. Exhaust blower shall meet noise and vibration criteria.

9. Lighting: Provide LED fixtures with wiring and hookup. Coordinate with emergency lighting requirements. Provide emergency lighting integral with portion of normal car lighting. Provide required transformer.

10. Suspended Ceiling: Six-section satin finish stainless steel panels with lighting cutouts in each panel. Design per architectural plans and drawings

11. Handrails: Minimum 1¼" diameter aluminum tubular grab bar with backing plates and captive nuts across rear and side walls. Bolt rails through car walls from back and mount on 1½" deep solid round stainless steel standoff spacers no more than 18" O.C. Return handrail/guardrail ends to car walls.

12. Cab Air Conditioner Unit: Provide self-contained cab air conditioner/heater on car top with concealed ducts, thermostat control, and evaporator. Isolate from car top to comply with noise and vibration requirements.

13. Auxiliary power for ventilation on observation elevators.

14. For interior floor Finish, see Section 09 67 70 – Elevator Spray on flooring.

2.11 HALL CONTROL STATIONS

A. Pushbuttons: Provide one riser per elevator with flush mounted faceplates. Include pushbuttons for each direction of travel that illuminate to indicate call registration. Include approved engraved message and engraved pictorial representation prohibiting use of elevator during fire or other emergency as part of faceplate. Pushbutton design shall match car operating panel pushbuttons. Provide vandal resistant pushbutton and light assemblies. Provide LED illumination.

B. Phase I Fire Service fixture, including keyswitch, engraved operating instructions and illuminating jewel. Provide illuminating jewels indicating standby power status.

2.12 SIGNALS

A. Car Direction Lantern Elevators 1-3:

1. Provide flush-mounted car lantern in all car entrance columns.

2. Illuminate up or down LED lights and sound tone once for up and twice for down direction. Illuminate light until the car doors start to close.

3. Sound level shall be adjustable from 20-80 dBA measured at 5'-0" in front of hall control station and 3'-0" off floor.

4. Provide adjustable car door dwell time to comply with ADA requirements relative to hall call notification time.

5. Car direction lenses shall be arrow shaped with faceplates.

6. Lenses shall be minimum 2½" in their smallest dimension.

7. Provide vandal resistant lantern and light assemblies consisting of series of dots or lines for maximum visibility.

B. Car Position Indicator:

1. Alpha-numeric digital indicator containing floor designations and direction arrows a minimum of 1/2" high to indicate floor served and direction of car travel. Locate fixture in car operating panel. When a car leaves or passes a floor, illuminate indication representing position of car in hoistway. Illuminate proper direction arrow to indicate direction of travel.

2. In addition to position and direction, the display shall interface with the elevator control system to provide system-based messages for the following conditions at a minimum:

   a. Firefighters' Service, Phase I

   b. Independent Service

   c. Earthquake Alert

C. Faceplate Material and Finish: Satin finish stainless steel, all fixtures. Tamper resistant fasteners for all fastenings exposed to the public.

D. Floor Passing Tone: Provide an audible tone of no less than 20 decibels and frequency of no higher than 1500 Hz, to sound as the car passes or stops at a floor served.

E. Voice Synthesizer: Provide electronic device with easily reprogrammable message and female voice to announce car direction, floor, emergency exiting instructions, etc.

F. Firefighters' Key Box: Flush-mounted box with lockable hinged cover. Engrave instructions for use on cover per Local Fire Authority requirements.

2.13 INTERCOM AND DISTRESS SIGNAL SYSTEM

A. General: Provide intercommunication system for all cars. Include all wiring between elevator hoistways and control panels. Include the following stations:

Station Location	Type Station	Selection Buttons to Call
Elevator Machine Room	Master	Control Panels, All Cars
Lobby Control Panel	Master	Machine Rooms, All Cars
Firefighters' Control Panel	Master	Machine Rooms, All Cars
All Cars	Remote	Lobby Control Panel

B. Basic Equipment:

1. Amplifier providing static-free voice transmission with adequate volume and minimum distortion at all stations, with pre-amplifier capable of receiving voice and music inputs from building and emergency building communication system.

2. Activation of emergency building communication system overrides all other conversations and permits one-way conversation to all master stations in system.

3. Master Stations:

   a. Speaker-microphone combination and/or handset for two-way communication.

   b. Selection buttons to enable communication with all master stations. Maintain continual reception of hands-free reply from station when a selected button is depressed.

   c. Two-Position "Talk/Listen" Button: Press to talk; release to listen.

   d. Illuminate "in use" light when any master station is being used.

   e. Reset button to make system available for use by any master station.

   f. Volume control knob for adjustment of incoming volume.

   g. Button to establish communications with all stations.

   h. Distress light in lobby panel which illuminates when "push to call" button or alarm button in car is actuated. Energize distress light and buzzer or chime until intercom selection button for that car has been depressed. Sound buzzer or chime in lobby panel simultaneously with illumination of distress light.

4. Remote Stations:

   a. Station in car shall be activated by "push to call," two-way communication button. "Push to call" button shall illuminate and flash when call is acknowledged. Button shall match car operating panel pushbutton design. Provide uppercase “PUSH TO CALL,” “HELP ON THE WAY” engraved signage adjacent to button. Provide “push to call” button tactile symbol, engraved signage, and Braille adjacent to button.

b. Locate car microphone and speaker, or transceiver/speaker combination behind front return panel with drilled speaker pattern, with shielded wiring to machine room junction box.

C. Station Housings:

1. House master station in machine room in a metal compartment with baked enamel finish. Attach to the group elevator supervisory control panel or wall mount. Provide communication handset with 25'-0" long cord.

2. Provide control center master intercoms with stainless steel satin finish faceplates and engraved operating instructions. Coordinate faceplate size and installation of units with building Console Supplier.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Prior to beginning installation of equipment examine hoistway and machine room areas. Verify no irregularities exist which affect execution of work specified.

B. Do not proceed with installation until work in place conforms to project requirements.

3.02 INSTALLATION

A. Install all equipment in accordance with Contractor’s instructions, referenced codes, specification, and approved submittals.

B. Install machine room equipment with clearances in accordance with referenced codes and specification.

C. Install all equipment so it may be easily removed for maintenance and repair.

D. Install all equipment for ease of maintenance.

E. Install all equipment to afford maximum accessibility, safety, and continuity of operation.

F. Remove oil, grease, scale, and other foreign matter from the following equipment and apply one coat of field-applied machinery enamel.

1. All exposed equipment and metal work installed as part of this work which does not have architectural finish.

2. Machine room equipment, hoistway equipment including guide rails, guide rail brackets, and pit equipment.

3. Neatly touch up damaged factory-painted surfaces with original paint color. Protect machine-finish surfaces against corrosion.

G. Clean all architectural finishes and replace or restore any surfaces damaged during construction to like new condition.

3.03 FIELD QUALITY CONTROL

A. Acceptance Testing: On completion of elevator installation and before permitting elevator use (either temporary or permanent), perform acceptance tests as required and recommended by ASME A17.1/CSA B44 and by governing regulations and agencies.

B. Operating Test: Load each elevator to rated capacity and operate continuously for thirty minutes over full travel distance, stopping at each level and proceeding immediately to the next. Record temperature rise of elevator machine during thirty-minute test period. Record failure to perform as required.

C. Advise Owner, Architect, and authorities having jurisdiction in advance of dates and times that tests are to be performed on elevators.

3.04 ADJUSTING

A. Install hydraulic jack assembly and guide rails plumb and align vertically with tolerance of 1/16" in 100'-0". Secure guide rail joints without gaps and file any irregularities to a smooth surface.

B. Static balance car to equalize pressure of guide shoes on guide rails.

C. Lubricate all equipment in accordance with Contractor’s instructions.

D. Adjust motors, valves, controllers, leveling switches, limit switches, stopping switches, door operators, interlocks, and safety devices to achieve required performance levels.

3.05 CLEANUP

A. Keep work areas orderly and free from debris during progress of project. Remove packaging materials on a daily basis.

B. Remove all loose materials and filings resulting from work.

C. Clean machine room equipment and floor.

D. Clean pit equipment and floor.

E. Clean hoistways, car, car enclosure, entrances, operating, and signal fixtures.

3.06 TEST RESULTS

A. Under any load obtain specified contract speed, performance times, stopping accuracy without re-leveling, and ride quality to satisfaction of Consultant. Tests may be conducted under no load, balanced load, and full load conditions.

B. Consultant may test temperature rise in motor windings limited to 50° Celsius above ambient. A full-capacity one hour running test, stopping at each floor for ten seconds in up and down directions, may be required.

C. Engage a factory-authorized service representative to train Owner’s maintenance personnel to operate elevators.

D. Check operation of each elevator with Owner’s personnel present before date of Substantial Completion and again not more than one month before end of warranty period. Determine that operation systems and devices are functioning properly.

3.07 PROTECTION

A. Temporary Use: Comply with the following requirements for each elevator used for construction purposes:

1. Provide car with temporary enclosure, either within finished car or in place of finished car, to protect finishes from damage.

2. Provide strippable protective film on entrance and car doors and frames.

3. Provide padded wood bumpers on entrance door frames covering jambs and frame faces.

4. Provide other protective coverings, barriers, devices, signs, and procedures as needed to protect elevator and elevator equipment.

5. Do not load elevators beyond their rated weight capacity.

6. Engage elevator Installer to provide full maintenance service. Include preventive maintenance, repair, or replacement of worn or defective components, lubrication, cleanup, and adjustment as necessary for proper elevator operation at rated speed and capacity. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

7. Engage Elevator Installer to restore damaged work, if any, so no evidence remains of correction. Return items which cannot be refinished in the field to the shop, make required repairs, and refinish entire unit, or provide new units as required.

3.08 PURCHASER’S INFORMATION

A. Provide three sets of neatly bound written information necessary for proper maintenance and adjustment of equipment within thirty days following final acceptance. Final retention will be withheld until data is received by Purchaser and reviewed by Consultant. Include the following as minimums:

1. Straight-line wiring diagrams of "as-installed" elevator circuits with index of location and function of components. Provide one set reproducible master. Mount one set wiring diagrams on panels, racked, or similarly protected, in elevator machine room. Provide remaining set rolled and in a protective drawing tube. Maintain all drawing sets with addition of all subsequent changes. These diagrams are Purchaser's property.

2. Written Maintenance Control Program (MCP) specifically designed for the equipment included under this contract. Include any unique or product specific procedures or methods required to inspect or to test the equipment. In addition, identify weekly, bi-weekly, monthly, quarterly, and annual maintenance procedures, including statutory and other required equipment tests.

3. Lubrication instructions including recommended grade of lubricants.

4. Parts catalogs for all replaceable parts including ordering forms and instructions.

5. Four sets of keys for all switches and control features properly tagged and marked.

6. Neatly bound instructions explaining all operating features including all apparatus in the car and lobby control panels.

7. Neatly bound maintenance and adjustment instructions explaining areas to be addressed, methods and procedures to be used, and specified tolerances to be maintained for all equipment.

8. Diagnostic equipment complete with access codes, adjusters' manuals and set-up manuals for adjustment, diagnosis and troubleshooting of elevator system, and performance of routine safety tests.

B. Non-Proprietary Equipment Design: Provide three sets of neatly bound written information necessary for proper maintenance and adjustment for equipment of within thirty days following final acceptance. Final retention will be withheld until data is received by Purchaser and reviewed by Consultant. Include the following as minimums:

1. Straight-line wiring diagrams of "as-installed" elevator circuits, with index of location and function of components. Provide one set reproducible master. Mount one set wiring diagrams on panels, racked, or similarly protected, in elevator machine room. Provide remaining set rolled and in a protective drawing tube. Maintain all drawing sets with addition of all subsequent changes. These diagrams are Purchaser's property. A legend sheet shall be furnished with each set of drawings to provide the following information:

   a. Name and symbol of each relay, switch, or other apparatus.

   b. Location on drawings, drawing sheet number and area, and location of all contacts.

c. Location of apparatus, whether on controller or on car.

2. Written Maintenance Control Program (MCP) specifically designed for the equipment included under this contract. Include any unique or product specific procedures or methods required to inspect or test the equipment. In addition, identify weekly, bi-weekly, monthly, quarterly, and annual maintenance procedures, including statutory and other required equipment tests.

3. Printed instructions explaining all operating features.

4. Complete software documentation for all installed equipment.

5. Lubrication instructions, including recommended grade of lubricants.

6. Parts catalogs listing all replaceable parts including Contractor's identifying numbers and ordering instructions.

7. Four sets of keys for all switches and control features properly tagged and marked.

8. Diagnostic test devices together with all supporting information necessary for interpretation of test data and troubleshooting of elevator system, and performance of routine safety tests.

9. The elevator installation shall be a design which can be maintained by any licensed elevator maintenance company employing journeymen mechanics, without the need to purchase or lease additional diagnostic devices, special tools, or instructions from the original equipment Manufacturer.

    a. Provide onsite capability to diagnose faults to the level of individual circuit boards and individual discreet components for the solid state elevator controller.

    b. Provide a separate, detachable device, as required to the Purchaser as part of this installation if the equipment for fault diagnosis is not completely self-contained within the controller. Such device shall be in possession of and become property of the Purchaser.

    c. Installed equipment not meeting this requirement shall be removed and replaced with conforming equipment at no cost to the Purchaser.

10. Provide upgrades and/or revisions of software during the progress of the work, warranty period and the term of the ongoing maintenance agreement between the Purchaser and Contractor.

11. Contractor to submit procedure for Elevator Hoistway Glass Cleaning.

C. Preventive Maintenance Contract: Furnish properly executed contract for continuing, preventive maintenance. Utilize contract form herein provided, Vertical Transportation Preventive Maintenance Contract.

D. Acceptance of such records by Purchaser/Consultant shall not be a waiver of any Contractor deviation from Contract Documents or shop drawings or in any way relieve Contractor from his responsibility to perform work in accordance with Contract Documents.

END OF SECTION

SECTION 21 05 17

SLEEVES AND SLEEVE SEALS FOR FIRE-SUPPRESSION PIPING

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.
6. Silicone sealants.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.04 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.05 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 SLEEVES

A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop.

B. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, hot dipped galvanized, with plain ends and integral welded waterstop collar.

C. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.02 STACK-SLEEVE FITTINGS

A. Description: Manufactured, Dura-coated or Duco-coated cast-iron sleeve with integral clamping flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.03 SLEEVE-SEAL SYSTEMS

A. Description:

1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
2. Designed to form a hydrostatic seal of 20 psig minimum.
3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
4. Pressure Plates: Stainless steel, Type 316.
5. Connecting Bolts and Nuts: Stainless steel, Type 316**,** of length required to secure pressure plates to sealing elements.

2.04 GROUT

A. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.05 SILICONE SEALANTS

A. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C 920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.

B. Silicone Foam: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.01 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.
   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
3. Using grout or silicone sealant, seal space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.02 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Use silicone sealant to seal around the outside of stack-sleeve fittings.

B. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- or smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.03 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.04 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.05 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:
    a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves.
    b. Piping NPS 6 and Larger: Cast-iron pipe sleeves.
2. Exterior Concrete Walls below Grade:
    a. Piping Smaller Than NPS 6: Steel pipe sleeves with sleeve-seal system.
    b. Piping NPS 6 and Larger: Steel pipe sleeves with sleeve-seal system.
3. Concrete Slabs-on-Grade:
    a. Piping Smaller Than NPS 6: Steel pipe sleeves with sleeve-seal system.
    b. Piping NPS 6 and Larger: Steel pipe sleeves with sleeve-seal system.

4. Concrete Slabs above Grade:
   a. Piping Smaller Than NPS 6 : Steel pipe sleeves or Stack-sleeve fittings.
   b. Piping NPS 6 and Larger: Steel pipe sleeves.
5. Interior Partitions:
   a. Piping Smaller Than NPS 6: Steel pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel sheet sleeves .

END OF SECTION 21 05 17

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SECTION 21 05 18

ESCUTCHEONS FOR FIRE-SUPPRESSION 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. Escutcheons.
2. Floor plates.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Stainless-Steel Type: With polished stainless-steel finish.

B. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

2.2 FLOOR PLATES

A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stainless steel with polished stainless-steel finish.
c.
d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stainless steel with polished stainless-steel finish.
e. Bare Piping in Unfinished Service Spaces: One-piece cast brass with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor plate.
2. Existing Piping: Split floor plate.

3.2 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 21 05 18

SECTION 21 05 23

GENERAL-DUTY VALVES FOR FIRE PROTECTION 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. Check valves.
2. Bronze OS&Y gate valves.
3. Iron OS&Y gate valves.
4. NRS gate valves.
5. Indicator posts.
6. Trim and drain valves.

1.3 DEFINITIONS

A. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

B. NRS: Nonrising stem.

C. OS&Y: Outside screw and yoke.

D. SBR: Styrene-butadiene rubber.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, and weld ends.
3. Set valves open to minimize exposure of functional surfaces.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

D. Protect flanges and specialties from moisture and dirt.

1.6 MEASUREMENT AND PAYMENT

A. Measurement: Air Release Valve shall be measured per Unit (each).

B. Payment: The contract price paid per unit (each) for Air Release Valve shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in installing air release valve, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. UL Listed: Valves shall be listed in UL's "Online Certifications Directory" under the headings listed below and shall bear UL mark:

1. Main Level: HAMV - Fire Main Equipment.

   a. Level 1: HCBZ - Indicator Posts, Gate Valve.
   b. Level 1: HLOT - Valves.

      1) Level 3: HLUG - Ball Valves, System Control.
      2) Level 3: HLXS - Butterfly Valves.
      3) Level 3: HMER - Check Valves.
      4) Level 3: HMRZ - Gate Valves.

2. Main Level: VDGT - Sprinkler System & Water Spray System Devices.

   a. Level 1: VQGU - Valves, Trim and Drain.

B. Source Limitations for Valves: Obtain valves for each valve type from single manufacturer.

C. ASME Compliance:

1. ASME B16.1 for flanges on iron valves.
2. ASME B1.20.1 for threads for threaded-end valves.
3. ASME B31.9 for building services piping valves.

D. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

E. NFPA Compliance: Comply with NFPA 24 for valves.

F. Valve Pressure Ratings: Not less than the minimum pressure rating indicated or higher as required by system pressures.

G. Valve Sizes: Same as upstream piping unless otherwise indicated.

H. Valve Actuator Types:

1. Worm-gear actuator with handwheel for quarter-turn valves, except for trim and drain valves.
2. Handwheel: For other than quarter-turn trim and drain valves.
3. Handlever: For quarter-turn trim and drain valves NPS 2 and smaller.

2.2 CHECK VALVES

A. Description:

1. Standard: UL 312 and FM Global standard for swing check valves, Class Number 1210.
2. Minimum Pressure Rating: 175 psig.
3. Type: Single swing check.
4. Body Material: Cast iron, ductile iron, or bronze.
5. Clapper: Bronze, ductile iron, or stainless steel with elastomeric seal.
6. Clapper Seat: Brass, bronze, or stainless steel.
7. Hinge Shaft: Bronze or stainless steel.
8. Hinge Spring: Stainless steel.
9. End Connections: Flanged, grooved, or threaded.

2.3 BRONZE OS&Y GATE VALVES

A. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Bronze or brass.
4. Wedge: One-piece bronze or brass.
5. Wedge Seat: Bronze.
6. Stem: Bronze or brass.
7. Packing: Non-asbestos PTFE.
8. End Connections: Threaded.

2.4 IRON OS&Y GATE VALVES

A. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron, or bronze with elastomeric coating.

5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. End Connections: Grooved.

2.5 NRS GATE VALVES

A. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron with elastomeric coating.
5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. End Connections: Grooved.

2.6 INDICATOR POSTS

A. Description:

1. Standard: UL 789 and FM Global standard for indicator posts.
2. Type: Underground.
3. Base Barrel Material: Cast or ductile iron.
4. Extension Barrel: Cast or ductile iron.
5. Cap: Cast or ductile iron.
6. Operation: Wrench.

2.7 TRIM AND DRAIN VALVES

A. Ball Valves:
1. Description:

a. Pressure Rating: 175 psig.
b. Body Design: Two piece.
c. Body Material: Forged brass or bronze.
d. Port size: Full or standard.
e. Seats: PTFE.
f. Stem: Bronze or stainless steel.
g. Ball: Chrome-plated brass.
h. Actuator: Handlever.
i. End Connections for Valves NPS 1 through NPS 2-1/2 : Threaded ends.
j. End Connections for Valves NPS 1-1/4 and NPS 2-1/2 : Grooved ends.

B. Angle Valves:
1. Description:

a. Pressure Rating: 175 psig.
b. Body Material: Brass or bronze.
c. Ends: Threaded.
d. Stem: Bronze.
e. Disc: Bronze.
f. Packing: Asbestos free.
g. Handwheel: Malleable iron, bronze, or aluminum.

C. Globe Valves:
1. Description:

a. Pressure Rating: 175 psig.
b. Body Material: Bronze with integral seat and screw-in bonnet.
c. Ends: Threaded.
d. Stem: Bronze.
e. Disc Holder and Nut: Bronze.
f. Disc Seat: Nitrile.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 GENERAL REQUIREMENTS FOR VALVE INSTALLATION

A. Comply with requirements in the following Sections for specific valve installation requirements and applications:
1. Section 211200 "Fire-Suppression Standpipes" for application of valves in fire-suppression standpipes.

B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Install valves having threaded connections with unions at each piece of equipment arranged to allow easy access, service, maintenance, and equipment removal without system shutdown. Provide separate support where necessary.

E. Install valves in horizontal piping with stem at or above the pipe center.

F. Install valves in position to allow full stem movement.

G. Install valve tags. Comply with requirements in Section 210553 "Identification for Fire-Suppression Piping and Equipment" for valve tags and schedules and signs on surfaces concealing valves; and the NFPA standard applying to the piping system in which valves are installed. Install permanent identification signs indicating the portion of system controlled by each valve.

H. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections.

I. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

END OF SECTION 21 05 23

SECTION 21 05 48

VIBRATION AND SEISMIC CONTROLS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

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. Elastomeric isolation pads.
2. Pipe-riser resilient supports.
3. Seismic-restraint accessories.
4. Adhesive anchor bolts.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.

   a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
   b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, due to seismic forces required to select vibration isolators, and due to seismic restraints.
3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
4. Seismic-Restraint Details:

    a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
    b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for fire-suppression piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

1.7 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:
1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
2. Size: Factory or field cut to match requirements of supported equipment.
3. Pad Material: Oil and water resistant with elastomeric properties.
4. Surface Pattern: Ribbed pattern.
5. Infused nonwoven cotton or synthetic fibers.
6. Load-bearing metal plates adhered to pads.

2.2 PIPE-RISER RESILIENT SUPPORT

A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch- thick neoprene.

1. Vertical-Limit Stops: Hot-dipped Galvanized Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
2. Maximum Load Per Support: 500 psigon isolation material providing equal isolation in all directions.

2.3 RESTRAINT CHANNEL BRACINGS

A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted hot-dipped galvanized steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.4 SEISMIC-RESTRAINT ACCESSORIES

A. Hanger-Rod Stiffener: Hot-dipped Galvanized Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

B. Hinged and Swivel Brace Attachments: Multifunctional hot-dipped galvanized steel connectors for attaching hangers to rigid channel bracings.

C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and hot-dipped galvanized steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.5 ADHESIVE ANCHOR BOLTS

A. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with stainless steel for all applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by [an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete

B. Equipment Restraints:
   1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
   2. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

C. Piping Restraints:

   1. Comply with requirements in MSS SP-127.
   2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
   3. Brace a change of direction longer than 12 feet.
   4. Brace at end of line.

D. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

E. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

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

G. Drilled-in Anchors:

   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
   4. Set anchors to manufacturer's recommended torque, using a torque wrench.
   5. Install stainless-steel anchors for all applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 211200 "Fire-Suppression Standpipes," for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

END OF SECTION 21 05 48

SECTION 21 05 53

IDENTIFICATION FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

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. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Valve tags.
5. Warning tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment-Label Schedule: Include a listing of all equipment to be labeled and the proposed content for each label.

D. Valve Schedules: Valve numbering scheme.

1.4 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Stainless steel, 0.025 inch thick, with predrilled holes for attachment hardware.
2. Letter Color: Black.
3. Background Color: White.
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches , and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
6. Fasteners: Stainless-steel rivets or self-tapping screws.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

C. Equipment-Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, with predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Red.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F .

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service and showing flow direction according to ASME A13.1.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe-Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

E. Pipe-Label Colors:

1. Background Color: Safety Red.
2. Letter Color: White.
3. Stencil Paint: Safety Red, exterior, gloss, alkyd enamel. Paint may be in pressurized spray-can form.
4. Identification Paint: White, exterior, alkyd enamel. Paint may be in pressurized spray-can form.

2.4 VALVE TAGS

A. Description: Stamped or engraved with 1/4-inch letters for piping-system abbreviation and 1/2-inch numbers.

1. Tag Material: stainless steel, 0.025 inch thick, with predrilled holes for attachment hardware.
2. Fasteners: Brass wire-link chain.
3. Valve-Tag Color: Safety Red.
4. Letter Color: White.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.5 WARNING TAGS

A. Description: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of incompatible primers, paints, and encapsulants, as well as dirt, oil, grease, release agents, and other substances that could impair bond of identification devices.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be installed.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping: Painting of piping is specified in Section 099123 "Interior Painting."

B. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection excluding short takeoffs. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on [both sides of]through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit a view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 25 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes including pipes where flow is allowed in both directions.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in fire-suppression piping systems. List tagged valves in a valve-tag schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and with captions similar to those indicated in "Valve-Tag Size and Shape" Subparagraph below:

1. Valve-Tag Size and Shape:

    a. Fire-Suppression Standpipe: 2 inches, round .

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 21 05 53

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SECTION 21 11 19

FIRE DEPARTMENT CONNECTIONS

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. Yard-type fire-department connections.

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 each fire-department connection.

1.4 MEASUREMENT AND PAYMENT

A. Measurement: Manual Dry Type Freestanding Double Clapper Two-Way Inlet Fire Department Connection shall be measured per Unit (each)..

B. Payment: The contract price paid per unit (each) for Manual Dry Type Freestanding Double Clapper Two-Way Inlet Fire Department Connection shall include full compensation for furnishing all labor, materials, tools, equipment, supports and incidentals, and for doing all work involved in installing manual dry type freestanding double clapper two-way inlet fire department connection, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 - PRODUCTS

2.1 YARD-TYPE FIRE-DEPARTMENT CONNECTION

A. Standard: UL 405.

B. Type: Exposed, freestanding.

C. Pressure Rating: 175 psig minimum.

D. Body Material: Corrosion-resistant metal.

E. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.

F. Caps: Brass, lugged type, with gasket and chain.

G. Escutcheon Plate: Round, brass, floor type.

H. Outlet: Bottom, with pipe threads.

I. Number of Inlets: Two.

J. Sleeve: Brass.

K. Sleeve Height: 18 inches.

L. Escutcheon Plate Marking: Similar to " STANDPIPE."

M. Finish, Including Sleeve: Polished chrome plated.

N. Outlet Size: NPS 4.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of fire-department connections.

B. Examine roughing-in for fire-suppression standpipe system to verify actual locations of piping connections before fire-department connection installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall-type fire-department connections.

B. Install yard-type fire-department connections in concrete slab support. Comply with requirements for concrete in Section 033000 "Cast-in-Place Concrete."

C. Install two protective pipe bollards on sides of each fire-department connection. Comply with requirements for bollards in Section 055000 "Metal Fabrications."

D. Install automatic (ball-drip) drain valve at each check valve for fire-department connection.

END OF SECTION 21 11 19

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SECTION 21 12 00

FIRE-SUPPRESSION STANDPIPES

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. Pipes, fittings, and specialties.
2. Fire-protection specialty valves.
3. Hose connection.

B. Related Requirements:

1. Section 210523 "General-Duty Valves for Water-Based Fire-Suppression Piping."
2. Section 211119 "Fire-Department Connections" for exposed wall-mounted and yard fire hydrants.

1.3 DEFINITIONS

A. High-Pressure Standpipe Piping: Fire-suppression standpipe piping designed to operate at working pressure higher than standard 175 psig, but not higher than 250 psig.

B. Standard-Pressure Standpipe Piping: Fire-suppression standpipe piping designed to operate at working pressure 175 psig maximum.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product

B. Shop Drawings: For fire-suppression standpipes.

1. Include plans, elevations, sections, and attachment details.

C. Delegated-Design Submittal: For standpipe 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.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Fire-suppression standpipes, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Domestic water piping.

B. Qualification Data: For Installer and professional engineer.

C. Approved Standpipe Drawings: Working plans, prepared according to NFPA 14, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

D. Welding certificates.

E. Fire-hydrant flow test report.

F. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 14. Include "Contractor's Material and Test Certificate for Aboveground Piping" and "Contractor's Material and Test Certificate for Underground Piping."

G. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-suppression standpipes specialties to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing fire-suppression standpipes and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

    a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.

B. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. 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.

D. NFPA Standards: Fire-suppression standpipe equipment, specialties, accessories, installation, and testing shall comply with NFPA 14.

1.8 MEASUREMENT AND PAYMENT

A. Measurement:

1. Manual Dry Type Standpipe Above Ground and Manual Dry Type Standpipe Below Ground shall be measured per Linear Foot.
2. Manual Dry Type Freestanding Double Outlet Fire Hose Connection shall be measured per Unit (each).

B. Payment: The contract price paid per linear foot for Manual Dry Type Standpipe Above Ground, Manual Dry Type Standpipe Below Ground, and Manual Dry Type Freestanding Double Outlet Fire Hose Connection shall include full compensation for furnishing all labor, materials, tools, equipment, supports, excavation and backfill, and incidentals, and for doing all work involved in installing manual dry type standpipe above ground, manual dry type standpipe below ground, and manual dry type freestanding double outlet fire hose connection as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTIONS

A. Manual Dry-Type, Class I Standpipe System: Includes NPS 2-1/2 hose connections. Does not have permanent water supply. Piping is dry. Water must be pumped into standpipes to satisfy demand.

2.2 PERFORMANCE REQUIREMENTS

A. Standard-Pressure, Fire-Suppression Standpipe System Component: Listed for 175-psig minimum working pressure.

B. Fire-suppression standpipe design shall be approved by authorities having jurisdiction.

1. Minimum residual pressure at each hose-connection outlet is as follows:
   a. NPS 2-1/2 Hose Connections: 100 psig.

C. Seismic Performance: Fire-suppression standpipes shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

2.3 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials and for joining methods for specific services, service locations, and pipe sizes.

2.4 GALVANIZED-STEEL PIPE AND ASSOCIATED FITTINGS

A. Schedule 40: ASTM A 53/A 53M, Type E, Grade B; with factory- or field-formed ends to accommodate joining method.

B. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

C. Malleable-Iron Unions:

1. ASME B16.39, Class 150.
2. Hexagonal-stock body.
3. Ball-and-socket, metal-to-metal, bronze seating surface.
4. Threaded ends.

D. Flanges: ASME B16.1, Class 125, cast iron.

E. Appurtenances for Grooved-End, Galvanized-Steel Pipe:

1. Victaulic or Equal.
2. Fittings for Grooved-End, Galvanized-Steel Pipe: Galvanized, ASTM A 47/A 47M, malleable-iron casting; ASTM A 106/A 106M, steel pipe; or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
3. Fittings for Grooved-End, Galvanized-Steel Pipe:

   a. AWWA C606 for steel-pipe dimensions.
   b. Ferrous housing sections.
   c. EPDM-rubber gaskets suitable for hot and cold water.
   d. Bolts and nuts.
   e. Minimum Pressure Rating:

      1) NPS 8 and Smaller: 600 psig .

2.5 SPECIALTY VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or FM Global's "Approval Guide."
2. Pressure Rating:

   a. Standard-Pressure Piping Specialty Valves: 175 psig minimum.

3. Body Material: Cast or ductile iron.
4. Size: Same as connected piping.
5. End Connections: Flanged or grooved.

2.6 FIRE HOSE CONNECTIONS (For Fire Department Use)

A. Freestanding :
1. Standard: UL 405.
2. Type: Exposed, freestanding
3. Pressure Rating: 175 psig minimum.
4. Body Material: Cast brass angle inlet body.
5. Inlet Size: Bottom inlet, NPS 4 female pipe threads.
6. Number of Outlets/Hose Connections: Two.
7. Hose Outlet Size: NPS 2-1/2 Male hose thread with lugged cap, gasket, and chain, swivel inlet brass NRS hose gate with male hose thread outlet. Include hose valve threads according to NFPA 1963 and matching local fire-department threads.
8. Pattern: Angle.

9. Sleeve: Brass.
10. Sleeve Height: 18 inches.
11. Overall Height: 24 inches.
12. Escutcheon Plate: Round, brass, floor type.
13. Escutcheon Plate Marking: Similar to "DRY STANDPIPE".
14. Support: Anchor directly to concrete floor
15. Finish: Polished chrome-plated.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 14 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.

B. Report test results promptly and in writing.

3.2 EXAMINATION

A. Examine roughing-in for hose connections and stations to verify actual locations of piping connections before installation.

B. Examine walls and partitions for suitable thickness, fire- and smoke-rated construction, framing for hose-station cabinets, and other conditions where hose connections and stations are to be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

B. Piping Standard: Comply with requirements in NFPA 14 for installation of fire-suppression standpipe piping.

C. Install seismic restraints on piping. Comply with requirements in NFPA 13 for seismic-restraint device materials and installation.

D. Install listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install drain valves on standpipes. Extend drain piping to outside of building.

F. Install automatic (ball drip) drain valves to drain piping between fire-department connections and check valves. Drain to floor drain or outside building.

G. Install hangers and supports for standpipe system piping according to NFPA 14. Comply with requirements in NFPA 13 for hanger materials.

H. Drain dry-type standpipe system piping.

I. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

J. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

K. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 210518 "Escutcheons for Fire-Suppression Piping."

3.4 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

C. Ream ends of pipes and tubes, and remove burrs. Bevel plain ends of steel pipe.

D. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

E. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

F. 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.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

G. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.

H. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

I. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to "Quality Assurance" Article.

1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

J. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.5 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 14 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Specialty Valves:

1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.

3.6 HOSE-CONNECTION INSTALLATION

A. Install hose connections adjacent to standpipes.

B. Install freestanding hose connections for access and minimum passage restriction.

3.7 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 14.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect standpipe systems according to NFPA 14, "System Acceptance" Chapter.
4. Verify that equipment hose threads are same as local fire-department equipment.

C. Fire-suppression standpipe system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves.

3.10 PIPING SCHEDULE

A. Piping between Fire-Department Connections and Check Valves: Galvanized, standard-weight steel pipe with grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

B. Standard-pressure, dry-type fire-suppression standpipe piping, NPS 4 and smaller, shall be[one of] the following:
   1. Schedule 40, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

C. Standard-pressure, dry-type fire-suppression standpipe piping, NPS 5 and NPS 6, shall be the following:
   1. Schedule 40, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

END OF SECTION 21 12 00

SECTION 22 05 17

SLEEVES AND SLEEVE SEALS FOR PLUMBING 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. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.

1.3 ACTION SUBMITTALS

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

1.4 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Stainless steel.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.3 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi , 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.

   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.

3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.3 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:

    a. Piping Smaller Than NPS 6 : Galvanized-steel wall sleeves.

2. Concrete Slabs-on-Grade:

    a. Piping Smaller Than NPS 6 : Galvanized-steel-pipe sleeves with sleeve-seal system.

        1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Interior Partitions:

    a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves .

END OF SECTION 22 05 17

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SECTION 22 05 18

ESCUTCHEONS FOR PLUMBING 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. Escutcheons.
2. Floor plates.

1.3 ACTION SUBMITTALS

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

1.4 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

D. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.

E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed and exposed-rivet hinge, and spring-clip fasteners.

2.2 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.

1. Escutcheons for New Piping:

    a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
    b. Insulated Piping: One-piece, stamped-steel type.
    c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
    d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
    e. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
    f. Bare Piping in Equipment Rooms: One-piece, cast-brass type with polished, chrome-plated finish.

2. Escutcheons for Existing Piping:
    a. Insulated Piping: Split-plate, stamped-steel type with concealed or exposed-rivet hinge.
    b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
    c. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
    d. Bare Piping in Unfinished Service Spaces: Split-casting brass type with polished, chrome-plated finish.
    e. Bare Piping in Equipment Rooms: Split-casting brass type with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 22 05 18

SECTION 22 05 23.12

BALL VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:

1. Brass ball valves.
2. Bronze ball valves.
3. Steel ball valves.
4. Iron ball valves.

1.03 DEFINITIONS

A. CWP: Cold working pressure.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, and soldered ends.
3. Set ball valves open to minimize exposure of functional surfaces.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

1.06 MEASUREMENT AND PAYMENT

A. Measurement: Ball Valves For Plumbing Piping, of the various sizes shown in the schedule of items of the Bid Form, shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Ball Valves For Plumbing Piping, of the various sizes shown in the schedule of items of the Bid Form, shall include full compensation for furnishing all labor, materials, tools, equipment, supports and incidentals, and for doing all Work involved in constructing ball valves for plumbing piping complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 for flanges on steel valves.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.18 for solder-joint connections.
6. ASME B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 for valve materials for potable-water service.

D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. Valve Actuator Types:
1. Handlever: For quarter-turn valves smaller than NPS 4.

H. Valves in Insulated Piping:

1. Include 2-inch (50-mm) stem extensions.
2. Extended operating handles of nonthermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

2.02 BRASS BALL VALVES

A. Two-Piece, Brass Ball Valves with Full Port and Brass Trim:

1. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 600 psig .
c. Body Design: Two piece.
d. Body Material: Forged brass.
e. Ends: Threaded and soldered.
f. Seats: PTFEStem: Brass.
g. Ball: Chrome-plated brass.
h. Port: Full.

2.03 BRONZE BALL VALVES

A. Two-Piece, Bronze Ball Valves with Full Port, and Bronze or Brass Trim:

1. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 600 psig.
c. Body Design: Two piece.
d. Body Material: Bronze.
e. Ends: Threaded and soldered.
f. Seats: PTFE.
g. Stem: Bronze or brass.
h. Ball: Chrome-plated brass.
i. Port: Full.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.02 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install valve tags. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

3.03 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.

3.04 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
2. Two-piece, brass ball valves with full port and brass trim.
3. Two-piece, bronze ball valves with full port and bronze or brass trim.

END OF SECTION 22 05 23.12

SECTION 22 05 23.14

CHECK VALVES FOR PLUMBING 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. Bronze swing check valves.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene-diene terpolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

   1. Certification that products comply with NSF 61 Annex G[and NSF 372].

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooves, and weld ends.
   3. Set check valves in either closed or open position.

B. Use the following precautions during storage:

   1. Maintain valve end protection.
   2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

1.6 MEASUREMENT AND PAYMENT

A. Measurement: Check Valves For Plumbing Piping shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Check Valves For Plumbing Piping shall include full compensation for furnishing all labor, materials, tools, equipment, supports and incidentals, and for doing all Work involved in constructing check valves for plumbing piping complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for solder joint.
5. ASME B31.9 for building services piping valves.

C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

D. NSF Compliance: NSF 61 Annex G[and NSF 372] for valve materials for potable-water service.

E. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

F. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

G. Valve Sizes: Same as upstream piping unless otherwise indicated.

H. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE LIFT CHECK VALVES

2.3 BRONZE SWING CHECK VALVES

A. Bronze Swing Check Valves with Bronze Disc, Class 125:
1. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 200 psig .
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded or soldered. See valve schedule articles.
f. Disc: Bronze.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.

F. Install valve tags. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

B. End Connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded or soldered.

3.5 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze swing check valves with bronze disc, Class 125, with soldered end connections.

END OF SECTION 22 05 23.14

SECTION 22 05 29

HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

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. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Equipment supports.

B. Related Sections:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 220516 "Expansion Fittings and Loops for Plumbing Piping" for pipe guides and anchors.
3. Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment.

1.5 ACTION SUBMITTALS

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

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Pipe stands.
4. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

1.8 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts. Entire assembly must be hot-dipped galvanized.

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:
   1. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
   2. Standard: MFMA-4.
   3. Channels: Continuous slotted steel channel with inturned lips.
   4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
   5. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.
   6. Metallic Coating: Hot-dipped galvanized.

2.4 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength and vapor barrier.

B. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig minimum compressive strength.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type, stainless- steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

2.7 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, positioning system of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.8 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.9 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:
   1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:

   1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
   2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

G. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

H. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

J. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

K. Install lateral bracing with pipe hangers and supports to prevent swaying.

L. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

M. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

N. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

O. Insulated Piping:

   1. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

      a. Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

   2. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

      a. Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

   3. Shield Dimensions for Pipe: Not less than the following:

      a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.

b. NPS 4: 12 inches long and 0.06 inch thick.

4. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and metal framing systems and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
3. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
4. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.

2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

N. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

O. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

P. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

Q. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 22 05 29

SECTION 22 05 48

VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

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. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Housed-spring isolators.
4. Restrained-spring isolators.
5. Housed-restrained-spring isolators.
6. Elastomeric hangers.
7. Spring hangers.
8. Snubbers.
9. Restraint channel bracings.
10. Restraint cables.
11. Seismic-restraint accessories.
12. Mechanical anchor bolts.
13. Adhesive anchor bolts.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.

a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.

b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment.

C. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, due to seismic forces required to select vibration isolators, and due to seismic restraints.
3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
4. Seismic-Restraint Details:

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

b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for plumbing piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

1.7 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:
   1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
   2. Size: Factory or field cut to match requirements of supported equipment.
   3. Pad Material: Oil and water resistant with elastomeric properties.
   4. Surface Pattern: Ribbed pattern.
   5. Infused nonwoven cotton or synthetic fibers.
   6. Load-bearing metal plates adhered to pads.

2.2 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:.
   1. Mounting Plates:
      a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
      b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
   2. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.3 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:
1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

    a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
    b. Top housing with attachment and leveling bolt.

2.4 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:
1. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

    a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
    b. Top plate with threaded mounting holes.
    c. Internal leveling bolt that acts as blocking during installation.

2. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.5 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:
1. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.

    a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
    b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.6 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:
1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
2. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.7 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.8 SNUBBERS

A. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch air gap, and minimum 1/4-inch- thick resilient cushion.

2.9 RESTRAINT CHANNEL BRACINGS

A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.10 RESTRAINT CABLES

A. Restraint Cables: ASTM A 492 stainless-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.11 SEISMIC-RESTRAINT ACCESSORIES

A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

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

E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.12 MECHANICAL ANCHOR BOLTS

A. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.13 ADHESIVE ANCHOR BOLTS

A. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

D. Equipment Restraints:

1. Install seismic snubbers on plumbing equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

E. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet .

F. Install cables so they do not bend across edges of adjacent equipment or building structure.

G. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

H. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

I. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

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

K. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 221116 "Domestic Water Piping" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

END OF SECTION 22 05 48

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SECTION 22 05 53

IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

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. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Stencils.
5. Valve tags.
6. Warning tags.

1.3 ACTION SUBMITTALS

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

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: stainless steel, 0.025-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Letter Color: Black.
3. Background Color: White.
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
6. Fasteners: Stainless-steel rivets.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Red.

C. Background Color: Yellow.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/2 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

G. Fasteners: Stainless-steel rivets.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

2.4 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: stainless steel, 0.025-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link chain.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.5 WARNING TAGS

A. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches .
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping Color Coding: Painting of piping is specified in Section 099123 "Interior Painting."

B. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 25 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

D. Pipe Label Color Schedule:

1. Domestic Water Piping

   a. Background: Safety green.
   b. Letter Colors: White.

2. Sanitary Waste and Storm Drainage Piping:

    a. Background Color: Safety black.
    b. Letter Color: White.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

    a. Cold Water: 2 inches, round.
    b. Hot Water: 2 inches, round.

2. Valve-Tag Colors:

    a. Cold Water: Safety green.
    b. Hot Water: Safety green.

3. Letter Colors:

    a. Cold Water: White.
    b. Hot Water: White.

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 22 05 53

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SECTION 22 07 19

PLUMBING PIPING INSULATION

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 insulating the following plumbing piping services:
1. Domestic hot-water piping.
2. Storm-water piping exposed to freezing conditions.
3. Roof drains and rainwater leaders.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:

1. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
2. Jacket Materials for Pipe: 12 inches long by NPS 2.
3. Sheet Jacket Materials: 12 inches square.
4. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

1.9 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Mineral-Fiber, Preformed Pipe Insulation:
   1. Type I, 850 Deg F (454 Deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
   1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (at 43-mil dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180 deg F.
   3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
   4. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: 60 percent by volume and 66 percent by weight.
4. Color: White.

2.4 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.

   1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
   3. Service Temperature Range: 0 to plus 180 deg F.
   4. Color: White.

2.5 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
   1. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

   1. Verify that systems to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
   1. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.8 FINISHES

A. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

B. Do not field paint aluminum or stainless-steel jackets.

3.9 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.11 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Hot and Recirculated Hot Water:

1. NPS 1-1/4 and Smaller: Insulation shall be:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

2. NPS 1-1/2 and Larger: Insulation shall be:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

B. Stormwater and Overflow:

1. All Pipe Sizes: Insulation shall be:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

C. Roof Drain and Overflow Drain Bodies:

1. All Pipe Sizes: Insulation shall be:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

D. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F:

1. All Pipe Sizes: Insulation shall be:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. None.

D. Piping, Exposed:

1. None.

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SECTION 22 11 16

DOMESTIC WATER 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. Copper tube and fittings.
2. Piping joining materials.
3. Encasement for piping.
4. Transition fittings.
5. Dielectric fittings.

1.3 ACTION SUBMITTALS

A. Product Data: For transition fittings and dielectric fittings.

1.4 INFORMATIONAL SUBMITTALS

A. System purging and disinfecting activities report.

B. Field quality-control reports.

1.5 FIELD 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 VTA no fewer than ten days in advance of proposed interruption of water service.
2. Do not interrupt water service without VTA's written permission.

1.6 MEASUREMENT AND PAYMENT

A. Measurement: Domestic Water Piping shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Domestic Water Piping shall include full compensation for furnishing all labor, materials, tools, equipment, supports, excavation and backfill, and incidentals, and for doing all Work involved in constructing domestic water piping complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Potable-water piping and components shall comply with NSF 14 and NSF 61 Annex G. Plastic piping components shall be marked with "NSF-pw."

C. Comply with NSF Standard 372 for low lead.

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.

B. Soft Copper Tube: ASTM B 88, Type K water tube, annealed temper.

C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

F. Copper Unions:

1. MSS SP-123.
2. Cast-copper-alloy, hexagonal-stock body.
3. Ball-and-socket, metal-to-metal seating surfaces.
4. Solder-joint or threaded ends.

2.3 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:

1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
2. 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. Solder Filler Metals: ASTM B 32, lead-free alloys.

D. Flux: ASTM B 813, water flushable.

E. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.4 ENCASEMENT FOR PIPING

A. Standard: ASTM A 674 or AWWA C105/A21.5.

B. Form: Sheet or tube.

C. Color: Natural .

2.5 TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

2.6 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:
1. Standard: ASSE 1079.
2. Pressure Rating: 125 psig minimum at 180 deg F .
3. End Connections: Solder-joint copper alloy and threaded ferrous.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install underground copper tube in PE encasement according to ASTM A 674 or AWWA C105/A21.5.

D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 221119 "Domestic Water Piping Specialties."

E. Install shutoff valve immediately upstream of each dielectric fitting.

F. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 221119 "Domestic Water Piping Specialties."

G. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.

H. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

I. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

J. 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.

K. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

L. Install piping to permit valve servicing.

M. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

N. Install piping free of sags and bends.

O. Install fittings for changes in direction and branch connections.

P. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

Q. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 220519 "Meters and Gages for Plumbing Piping."

R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 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 pipes, tubes, 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.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.

E. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

F. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

1. Fittings for NPS 1-1/2 and Smaller: Fitting-type coupling.
2. Fittings for NPS 2 and Larger: Sleeve-type coupling.

3.5 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger, support products, and installation in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:

    a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
4. NPS 2-1/2: 108 inches with 1/2-inch rod.

F. Install supports for vertical copper tubing every 10 feet .

G. Support piping and tubing not listed in this article according to MSS SP-58 and manufacturer's written instructions.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:

1. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
2. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
3. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.8 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Label pressure piping with system operating pressure.

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Piping Inspections:

   a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
   b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

      1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
      2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.

   c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
   d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

2. Piping Tests:

   a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
   b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
   c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
   e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
   f. Prepare reports for tests and for corrective action required.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.

2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.

   a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
   b. Adjust calibrated balancing valves to flows indicated.

5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.11 CLEANING

A. Clean and disinfect potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:

   a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
   b. Fill and isolate system according to either of the following:

      1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
      2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.

   c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
   d. Repeat procedures if biological examination shows contamination.
   e. Submit water samples in sterile bottles to authorities having jurisdiction.

B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.12 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.

D. Under-building-slab, domestic water, building-service piping, NPS 3 and smaller, shall be:

1. Soft copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.

E. Under-building-slab, domestic water piping, NPS 2 and smaller, shall be:

1. Hard copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and brazed joints.

F. Aboveground domestic water piping, NPS 2 and smaller, shall be:

1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-]copper, solder-joint fittings; and soldered joints.

3.13 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use ball or gate valves for piping NPS 2 and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 and larger.
2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
3. Hot-Water Circulation Piping, Balancing Duty: Calibrated balancing valves.
4. Drain Duty: Hose-end drain valves.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

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SECTION 22 11 19

DOMESTIC WATER PIPING SPECIALTIES

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. Vacuum breakers.
2. Backflow preventers.
3. Water pressure-reducing valves.
4. Strainers.
5. Wall hydrants.
6. Ground hydrants.
7. Drain valves.
8. Water-hammer arresters.
9. Air vents.
10. Trap-seal primer valves.
11. Trap-seal primer systems.
12. Specialty valves.
13. Flexible connectors.

B. Related Requirements:

1. Section 220519 "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
2. Section 221116 "Domestic Water Piping" for water meters.
3. Section 224500 "Emergency Plumbing Fixtures" for water tempering equipment.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For domestic water piping specialties.

1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

1.6 MEASUREMENT AND PAYMENT

A. Measurement: Domestic Water Piping Specialties shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Domestic Water Piping Specialties shall include full compensation for furnishing all labor, materials, tools, equipment, supports and incidentals, and for doing all Work involved in constructing domestic water piping specialties complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

A. Potable-water piping and components shall comply with NSF 61 Annex G and NSF 14.

2.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

2.3 VACUUM BREAKERS

A. Hose-Connection Vacuum Breakers:
1. Standard: ASSE 1011.
2. Body: Bronze, nonremovable, with manual drain.
3. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
4. Finish: Chrome or nickel plated.

2.4 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:
1. Standard: ASSE 1013.
2. Operation: Continuous-pressure applications.
3. Pressure Loss: 12 psig maximum, through middle third of flow range.

4. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 (DN 65) and larger.
5. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
6. Configuration: Designed for horizontal, straight-through flow.
7. Accessories:

   a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
   b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
   c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

B. Hose-Connection Backflow Preventers:
1. Standard: ASSE 1052.
2. Operation: Up to 10-foot head of water back pressure.
3. Inlet Size: NPS 1/2 or NPS 3/4.
4. Outlet Size: Garden-hose thread complying with ASME B1.20.7.
5. Capacity: At least 3-gpm flow.

C. Backflow-Preventer Test Kits:
1. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.5 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:
1. Standard: ASSE 1003.
2. Pressure Rating: Initial working pressure of 150 psig.
3. Body: Bronze with chrome-plated finish for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
4. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

2.6 HOSE BIBBS

2.7 WALL HYDRANTS

A. Moderate-Climate Wall Hydrants:
1. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
2. Pressure Rating: 125 psig.
3. Operation: Loose key.
4. Inlet: NPS 3/4.
5. Outlet:

   a. Concealed, with integral vacuum breaker or nonremovable hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
   b. Garden-hose thread complying with ASME B1.20.7.

6. Box: Deep, flush mounted with cover.
7. Box and Cover Finish: Chrome plated.
8. Outlet:

a. Concealed, with integral vacuum breaker or nonremovable hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
b. Garden-hose thread complying with ASME B1.20.7.
9. Operating Key(s): One with each wall hydrant.

2.8 GROUND HYDRANTS

A. Nonfreeze Ground Hydrants:
1. Standard: ASME A112.21.3M.
2. Type: Nonfreeze, concealed-outlet ground hydrant with box.
3. Operation: Loose key.
4. Casing and Operating Rod: Of at least length required for burial of valve below frost line.
5. Inlet: NPS 3/4.
6. Outlet: Garden-hose thread complying with ASME B1.20.7.
7. Drain: Designed with hole to drain into ground when shut off.
8. Box: Standard pattern with cover.
9. Box and Cover Finish: Polished nickel bronze.
10. Operating Key(s): One with each ground hydrant.
11. Vacuum Breaker: ASSE 1011.

2.9 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

2.10 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters :
1. Standard: ASSE 1010 or PDI-WH 201.
2. Type: Copper tube with piston.
3. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.11 TRAP-SEAL PRIMER DEVICE

A. Supply-Type, Trap-Seal Primer Device <Insert drawing designation if any>:
1. Standard: ASSE 1018.
2. Pressure Rating: 125 psig minimum.
3. Body: Bronze.

4. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
5. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
6. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

2.12 SPECIALTY VALVES

A. Comply with requirements for general-duty metal valves in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," Section 220523.14 "Check Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."

2.13 FLEXIBLE CONNECTORS

A. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig.
2. End Connections NPS 2 and Smaller: Threaded steel-pipe nipple.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.
2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
3. Do not install bypass piping around backflow preventers.

B. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.

C. Install balancing valves in locations where they can easily be adjusted.

D. Install Y-pattern strainers for water on supply side of each water pressure-reducing valve.

E. Install ground hydrants with 1 cu. yd. of crushed gravel around drain hole. Set ground hydrants with box flush with grade.

F. Install water-hammer arresters in water piping according to PDI-WH 201.

G. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

3.2 CONNECTIONS

A. Comply with requirements for ground equipment in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Fire-retardant-treated-wood blocking is specified in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical connections.

3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
   1. Reduced-pressure-principle backflow preventers.
   2. Water pressure-reducing valves.
   3. Supply-type, trap-seal primer valves.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

   1. Test each reduced-pressure-principle backflow preventer according to authorities having jurisdiction and the device's reference standard.

B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow set points of balancing valves.

END OF SECTION 22 11 19

SECTION 22 13 16

SANITARY WASTE AND VENT 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, tube, and fittings.
2. Specialty pipe fittings.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For hubless, single-stack drainage system. Include plans, elevations, sections, and details.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For waste and vent piping, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.5 FIELD CONDITIONS

A. Interruption of Existing Sanitary Waste 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 VTA no fewer than ten days in advance of proposed interruption of sanitary waste service.
2. Do not proceed with interruption of sanitary waste service without VTA's written permission.

1.6 MEASUREMENT AND PAYMENT

A. Measurement: Sanitary Waste And Vent Piping shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Sanitary Waste And Vent Piping shall include full compensation for furnishing all labor, materials, tools, equipment, supports, excavation and backfill, and incidentals, and for doing all Work involved in constructing sanitary waste and vent piping complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Soil, Waste, and Vent Piping: 10-foot head of water.

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

2.2 PIPING MATERIALS

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Heavy-Duty, Hubless-Piping Couplings:

1. Standards: ASTM C 1277 and ASTM C 1540.
2. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.4 COPPER TUBE AND FITTINGS

A. Copper Type DWV Tube: ASTM B 306, drainage tube, drawn temper.

B. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

C. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.5 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
2. Unshielded, Nonpressure Transition Couplings:

    a. Standard: ASTM C 1173.
    b. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
    c. End Connections: Same size as and compatible with pipes to be joined.
    d. Sleeve Materials:

        1) For Cast-Iron Soil Pipes: ASTM C 564, rubber.
        2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
        3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

3. Shielded, Nonpressure Transition Couplings:

    a. Standard: ASTM C 1460.
    b. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
    c. End Connections: Same size as and compatible with pipes to be joined.

B. Dielectric Fittings:

1. Dielectric Unions:

    a. Description:

        1) Standard: ASSE 1079.
        2) Pressure Rating: 125 psig minimum at 180 deg F.
        3) End Connections: Solder-joint copper alloy and threaded ferrous.

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.

1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
2. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

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 above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

K. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.

1. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical.
2. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe.

    a. Straight tees, elbows, and crosses may be used on vent lines.

3. Do not change direction of flow more than 90 degrees.
4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.

    a. Reducing size of waste piping in direction of flow is prohibited.

L. Lay buried building waste piping beginning at low point of each system.

1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
3. Maintain swab in piping and pull past each joint as completed.

M. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:

1. Building Sanitary Waste: 2 percent downward in direction of flow for piping NPS 3 and smaller; 2 percent downward in direction of flow for piping NPS 4 and larger.

2. Horizontal Sanitary Waste Piping: 2 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

N. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping according to ASTM A 674 or AWWA C105/A 21.5.

O. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."

P. Install engineered soil and waste and vent piping systems as follows:

1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
2. Hubless, Single-Stack Drainage System: Comply with ASME B16.45 and hubless, single-stack aerator fitting manufacturer's written installation instructions.
3. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.

Q. Plumbing Specialties:

1. Install backwater valves in sanitary waster gravity-flow piping.

    a. Comply with requirements for backwater valves specified in Section 221319 "Sanitary Waste Piping Specialties."

2. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.

    a. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping.
    b. Comply with requirements for cleanouts specified in Section 221319 "Sanitary Waste Piping Specialties."

3. Install drains in sanitary waste gravity-flow piping.

    a. Comply with requirements for drains specified in Section 221319 "Sanitary Waste Piping Specialties."

R. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

S. Install sleeves for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

T. Install sleeve seals for piping penetrations of concrete walls and slabs.

1. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

B. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1.

1. Cut threads full and clean using sharp dies.
2. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
c. Do not use pipe sections that have cracked or open welds.

C. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in ODs.
2. In Waste Drainage Piping: Shielded, nonpressure transition couplings.
3. In Aboveground Force Main Piping: Fitting-type transition couplings.

B. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.

3.5 VALVE INSTALLATION

A. Comply with requirements in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," Section 220523.14 "Check Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping" for general-duty valve installation requirements.

B. Backwater Valves: Install backwater valves in piping subject to backflow.

1. Horizontal Piping: Horizontal backwater valves. Use normally closed type unless otherwise indicated.
2. Floor Drains: Drain outlet backwater valves unless drain has integral backwater valve.
3. Install backwater valves in accessible locations.

4. Comply with requirements for backwater valve specified in Section 221319 "Sanitary Waste Piping Specialties."

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Install hot-dipped galvanized carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install hot-dipped galvanized carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
3. Vertical Piping: MSS Type 8 or Type 42, clamps.
4. Install individual, straight, horizontal piping runs:

   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet : MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.

5. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
6. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support horizontal piping and tubing within 12 inches of each fitting[, valve,] and coupling.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
5. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

G. Install supports for vertical cast-iron soil piping every 15 feet .

H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4: 72 inches with 3/8-inch rod.
2. NPS 1-1/2 and NPS 2 : 96 inches with 3/8-inch rod.

I. Install supports for vertical copper tubing every 10 feet .

J. Support piping and tubing not listed above according to MSS SP-58 and manufacturer's written instructions.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect waste and vent piping to the following:

1. Plumbing Fixtures: Connect waste piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect waste and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
5. Install horizontal backwater valves with cleanout cover flush with floor.
6. Comply with requirements for backwater valves, cleanouts and drains specified in Section 221319 "Sanitary Waste Piping Specialties."
7. Equipment: Connect waste piping as indicated.

   a. Provide shutoff valve if indicated and union for each connection.
   b. Use flanges instead of unions for connections NPS 2-1/2 and larger.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

E. Make connections according to the following unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.

3.8 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping.

B. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.

2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary waste and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.

   a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced waste and vent piping until it has been tested and approved.

   a. Expose work that was covered or concealed before it was tested.

3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.

   a. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water.
   b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
   c. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight.

   a. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg.
   b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
   c. Air pressure must remain constant without introducing additional air throughout period of inspection.
   d. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.10 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect sanitary waste and vent piping during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

D. Repair damage to adjacent materials caused by waste and vent piping installation.

3.11 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground, soil and waste piping NPS 4 and smallershall be:
   1. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
   2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

C. Aboveground, soil and waste piping NPS 5 and larger shall be:
   1. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
   2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

D. Aboveground, vent piping NPS 4 and smaller shall be:
   1. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
   2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

E. Underground, soil, waste, and vent piping NPS 4 and smaller shall be:
   1. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
   2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

F. Underground, soil and waste piping NPS 5 and larger shall be:
   1. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; coupled joints.
   2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

END OF SECTION 22 13 16

SECTION 22 13 19

SANITARY WASTE PIPING SPECIALTIES

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. Cleanouts.
   2. Roof flashing assemblies.
   3. Through-penetration firestop assemblies.
   4. Miscellaneous sanitary drainage piping specialties.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene.

B. FOG: Fats, oils, and greases.

C. PVC: Polyvinyl chloride.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, and accessories.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sanitary waste piping specialties to include in emergency, operation, and maintenance manuals.

1.6 MEASUREMENT AND PAYMENT

A. Measurement: Sanitary Waste Piping Specialties shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Sanitary Waste Piping Specialties shall include full compensation for furnishing all labor, materials, tools, equipment, supports, excavation and backfill, and incidentals, and for doing all Work involved in constructing sanitary waste piping specialties complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

A. Sanitary waste piping specialties shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14 for plastic sanitary waste piping specialty components.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing, and marked for intended location and application.

2.2 BACKWATER VALVES

A. Horizontal, Cast-Iron Backwater Valves :

1. Standard: ASME A112.14.1.
2. Size: Same as connected piping.
3. Body: Cast iron.
4. Cover: Cast iron with bolted or threaded access check valve.
5. End Connections: Hubless.
6. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang closed.
7. Extension: ASTM A 74, Service class; full-size, cast-iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

B. Drain-Outlet Backwater Valves :

1. Size: Same as floor drain outlet.
2. Body: Cast iron or bronze made for vertical installation in bottom outlet of floor drain.
3. Check Valve: Removable ball float.
4. Inlet: Threaded.
5. Outlet: Threaded.

2.3 CLEANOUTS

A. Cast-Iron Exposed Cleanouts:

1. Standard: ASME A112.36.2M.
2. Size: Same as connected drainage piping
3. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
4. Closure: Countersunk or raised-head, cast-iron plug.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Cast-Iron Exposed Floor Cleanouts:

1. Standard: ASME A112.36.2M for cast-iron soil pipe with cast-iron ferrule cleanout.
2. Size: Same as connected branch.
3. Type: Cast-iron soil pipe with cast-iron ferrule.
4. Body or Ferrule: Cast iron.
5. Clamping Device: Not required.
6. Outlet Connection: Threaded.
7. Closure: Cast-iron plug.
8. Adjustable Housing Material: Cast iron with threads.
9. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
10. Frame and Cover Shape: Round.
11. Top Loading Classification: Heavy Duty.
12. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts <Insert Drawing designation, if any>:

1. Standard: ASME A112.36.2M. Include wall access.
2. Size: Same as connected drainage piping.
3. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
4. Closure Plug:
    a. Cast iron.
    b. Countersunk or raised head.
    c. Drilled and threaded for cover attachment screw.
    d. Size: Same as or not more than one size smaller than cleanout size.
5. Wall Access: Round, flat, stainless-steel cover plate with screw.

2.4 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:

1. Description: Manufactured assembly made of 6.0-lb/sq. ft., 0.0938-inch- thick, lead flashing collar and skirt extending at least 8 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.
    a. Open-Top Vent Cap: Without cap.

2.5 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies :

1. Standard: UL 1479 assembly of sleeve-and-stack fitting with firestopping plug.
2. Size: Same as connected soil, waste, or vent stack.
3. Sleeve: Molded-PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.

2.6 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Deep-Seal Traps:

1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
2. Size: Same as connected waste piping.

a. NPS 2: 4-inch- minimum water seal.
b. NPS 2-1/2 and Larger: 5-inch- minimum water seal.

B. Floor-Drain, Trap-Seal Primer Fittings:

1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

C. Air-Gap Fittings:

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install backwater valves in building drain piping.

1. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.

B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.

C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

E. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof. Comply with requirements in Section 076200 "Sheet Metal Flashing and Trim."

F. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof. Comply with requirements in Section 076200 "Sheet Metal Flashing and Trim."

G. Install through-penetration firestop assemblies in plastic conductors and stacks at floor penetrations.

1. Comply with requirements in Section 078413 "Penetration Firestopping."

H. Install deep-seal traps on floor drains and other waste outlets, if indicated.

I. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.

1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
2. Size: Same as floor drain inlet.

J. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

K. Install sleeve and sleeve seals with each riser and stack passing through floors with waterproof membrane.

L. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

M. Install wood-blocking reinforcement for wall-mounting-type specialties.

N. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2 CONNECTIONS

A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

3.3 FLASHING INSTALLATION

A. Comply with requirements in Section 076200 "Sheet Metal Flashing and Trim."

B. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required.

C. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.

2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

D. Set flashing on floors and roofs in solid coating of bituminous cement.

E. Secure flashing into sleeve and specialty clamping ring or device.

F. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Section 076200 "Sheet Metal Flashing and Trim."

G. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

3.4 LABELING AND IDENTIFYING

A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit.

1. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 13 19

SECTION 22 14 13

FACILITY STORM 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, tube, and fittings.
2. Specialty pipe fittings.

1.3 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Storm Drainage Piping: 10-foot head of water.

B. Seismic Performance: Storm drainage piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1.4 ACTION SUBMITTALS

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

B. Sustainable Design Submittals:

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For storm drainage piping, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

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 VTA no fewer than ten days in advance of proposed interruption of storm-drainage service.
2. Do not proceed with interruption of storm-drainage service without VTA's written permission.

1.8 MEASUREMENT AND PAYMENT

A. Measurement: Facility Storm Drainage Piping shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Facility Storm Drainage Piping shall include full compensation for furnishing all labor, materials, tools, equipment, supports, excavation and backfill, and incidentals, and for doing all Work involved in constructing facility storm drainage piping complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Heavy-Duty, Hubless-Piping Couplings:
1. Standards: ASTM C 1277 and ASTM C 1540.
2. Description: Heavy-duty Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.3 GALVANIZED-STEEL PIPE AND FITTINGS

A. Galvanized-Steel Pipe: ASTM A 53/A 53M, Type E, Standard Weight. Include threaded ends matching joining method.

B. Steel-Pipe Pressure Fittings:

1. Galvanized-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106/A 106M, Schedule 40, seamless steel pipe. Include ends matching joining method.

2. 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.

3. Galvanized-Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, standard pattern.

2.4 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. General Requirements: Fitting or device for joining piping with small differences in ODs or of different materials. Include end connections same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified-piping-system fitting.

3. Shielded, Nonpressure Transition Couplings:
   a. Standard: ASTM C 1460.
   b. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

4. Pressure Transition Couplings:
   a. Standard: AWWA C219.
   b. Description: Metal, sleeve-type couplings same size as, with pressure rating at least equal to and ends compatible with, pipes to be joined.
   c. Center-Sleeve Material: Carbon steel.
   d. Gasket Material: Natural or synthetic rubber.
   e. Metal Component Finish: Corrosion-resistant coating or material.

B. Dielectric Fittings:

1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
2. Dielectric Unions:
   a. Description:

      1) Standard: ASSE 1079.
      2) Pressure Rating: 150 psig.
      3) End Connections: Solder-joint copper alloy and threaded ferrous.

3. Dielectric Flanges:
   a. Description:

      1) Standard: ASSE 1079.
      2) Factory-fabricated, bolted, companion-flange assembly.
      3) Pressure Rating: 150 psig.
      4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

A. 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 from layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

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 above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

K. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

L. Lay buried building storm drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

M. Install storm drainage piping at the following minimum slopes unless otherwise indicated:

1. Building Storm Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 2 percent downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.

N. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

O. Install steel piping according to applicable plumbing code.

P. Plumbing Specialties:

1. Install backwater valves in storm drainage gravity-flow piping. Comply with requirements for backwater valves specified in Section 221423 "Storm Drainage Piping Specialties."
2. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping. Comply with requirements for cleanouts specified in Section 221423 "Storm Drainage Piping Specialties."
3. Install drains in storm drainage gravity-flow piping. Comply with requirements for drains specified in Section 221423 "Storm Drainage Piping Specialties."

Q. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Hubless, Cast-Iron Soil Piping Coupled Joints: Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

B. 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.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in ODs.
2. In Drainage Piping: Shielded, nonpressure transition couplings.
3. In Aboveground Force-Main Piping: Fitting-type transition couplings.
4. In Underground Force-Main Piping:

a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
b. NPS 2 and Larger: Pressure transition couplings.

B. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.
3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

3.5 VALVE INSTALLATION

A. General valve installation requirements are specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.14 "Check Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."

B. Backwater Valves: Install backwater valves in piping subject to backflow.

1. Horizontal Piping: Horizontal backwater valves. Use normally closed type unless otherwise indicated.
2. Install backwater valves in accessible locations.
3. Comply with requirements for backwater valves specified in Section 221423 "Storm Drainage Piping Specialties."

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Install hot-dipped galvanized carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install hot-dipped galvanized carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
3. Vertical Piping: MSS Type 8 or Type 42, hot-dipped galvanized clamps.
4. Individual, Straight, Horizontal Piping Runs:

   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
5. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
4. Spacing for 10-foot pipe lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

G. Install supports for vertical cast-iron soil piping every 15 feet.

H. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4: 84 inches with 3/8-inch rod.
2. NPS 1-1/2: 108 inches with 3/8-inch rod.
3. NPS 2: 10 feet with 3/8-inch rod.
4. NPS 2-1/2: 11 feet with 1/2-inch rod.
5. NPS 3: 12 feet with 1/2-inch rod.
6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.

I. Install supports for vertical steel piping every 15 feet.

J. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect storm drainage piping to roof drains and storm drainage specialties.

1. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.
2. Install horizontal backwater valves with cleanout cover flush with floor.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

E. Make connections according to the following unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

A. Identify exposed storm drainage piping. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Test Procedure: Test storm drainage piping on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts until completion of inspection, water level must not drop. Inspect joints for leaks.
4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
5. Prepare reports for tests and required corrective action.

3.10 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.11 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground inside canopy structural steel tube storm drainage piping NPS 6 and smaller shall be:
1. Galvanized-steel pipe, pressure fittings, and threaded joints.
2. Fitting-type transition couplings if dissimilar pipe materials.

C. Aboveground storm drainage piping NPS 6 and smaller shall be:
1. Hubless, cast-iron soil pipe and fittings; heavy-duty, hubless-piping couplings; and coupled joints.

2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

D. Underground storm drainage piping NPS 6 and smaller shall be:
   1. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
   2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

END OF SECTION 22 14 13

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SECTION 22 14 23

STORM DRAINAGE PIPING SPECIALTIES

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. Roof drains.
2. Miscellaneous storm drainage piping specialties.
3. Cleanouts.
4. Backwater valves.
5. Through-penetration firestop assemblies.
6. Flashing materials.

1.3 ACTION SUBMITTALS

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

1.4 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

1.5 MEASUREMENT AND PAYMENT

A. Measurement: Storm Drainage Piping Specialties shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Storm Drainage Piping Specialties shall include full compensation for furnishing all labor, materials, tools, equipment, supports, excavation and backfill, and incidentals, and for doing all Work involved in constructing storm drainage piping specialties complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 METAL ROOF DRAINS

A. Cast-Iron, Roof Drains and Overflow Drains:
1. Standard: ASME A112.6.4, for general-purpose roof drains.
2. Body Material: Cast iron.
3. Dimension of Body: 8- to 12-inch diameter.
4. Combination Flashing Ring and Gravel Stop: Required.
5. Outlet: Bottom.
6. Underdeck Clamp: Required.
7. Sump Receiver Plate: Required.
8. Dome Material: Cast iron.
9. Water Dam: 2 inches high for overflow drain only.

B. Metal, Cornice and Gutter Roof Drains:
1. Standard: ASME A112.6.4, for cornice and gutter roof drains.
2. Body Material: Metal.
3. Dimension of Body: Nominal 6-inch diameter.
4. Outlet: Side.
5. Dome Material: Bronze.

2.2 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Downspout Nozzles:

1. Description: Bronze body with threaded inlet and bronze wall flange with mounting holes.
2. Size: Same as connected conductor.

2.3 BACKWATER VALVES

A. Cast-Iron, Horizontal Backwater Valves
1. Zurn or approved equal.
2. Standard: ASME A112.14.1, for backwater valves.
3. Size: Same as connected piping.
4. Body Material: Cast iron.
5. Cover: Cast iron with bolted or threaded access check valve.
6. End Connections: Hubless.
7. Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang closed.
8. Extension: ASTM A 74, Service class; full-size, cast-iron soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

2.4 CLEANOUTS

A. Floor Cleanouts:
1. Standard: ASME A112.36.2M, for heavy-duty, adjustable housing cleanouts.
2. Size: Same as connected branch.

3. Type: Heavy-duty, adjustable housing.
4. Body or Ferrule Material: Cast iron.
5. Outlet Connection: Threaded.
6. Closure: Cast-iron plug.
7. Adjustable Housing Material: Cast iron with threads.
8. Frame and Cover Material and Finish: Nickel-bronze, copper alloy .
9. Frame and Cover Shape: Round.
10. Top-Loading Classification: Heavy Duty.
11. Riser: ASTM A 74, Extra-Heavy class, cast-iron drainage pipe fitting and riser to cleanout.

2.5 FLASHING MATERIALS

A. Copper Sheet: ASTM B 152/B 152M,12 oz./sq. ft..

B. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.

C. Fasteners: Metal compatible with material and substrate being fastened.

D. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

E. Solder: ASTM B 32, lead-free alloy.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.

1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
2. Install expansion joints, if indicated, in roof drain outlets.
3. Position roof drains for easy access and maintenance.

B. Install downspout adapters on outlet of back-outlet parapet roof drains and connect to sheet metal downspouts.

C. Install downspout nozzles at exposed bottom of conductors where they spill onto grade.

D. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:

1. Use cleanouts the same size as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
3. Locate cleanouts at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate cleanouts at base of each vertical soil and waste stack.

E. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

F. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

G. Install horizontal backwater valves in floor with cover flush with floor.

H. Install test tees in vertical conductors and near floor.

I. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

J. Install through-penetration firestop assemblies in plastic conductors at concrete floor penetrations.

K. Install sleeve flashing device with each conductor passing through floors with waterproof membrane.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 221413 "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of 6.0-lb/sq. ft. lead sheets, 0.0938-inch thickness or thicker. Solder joints of 4.0-lb/sq. ft. lead sheets, 0.0625-inch thickness or thinner.
2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching the pipe size, with a minimum length of 10 inches and with skirt or flange extending at least 8 inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 14 23

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SECTION 22 33 00

ELECTRIC, DOMESTIC-WATER HEATERS

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. Commercial, electric, storage, domestic-water heaters.
2. Commercial, light-duty, storage, electric, domestic-water heaters.
3. Domestic-water heater accessories.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Commercial domestic-water heaters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.4 ACTION SUBMITTALS

A. Product Data: For each type and size of domestic-water heater indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For commercial domestic-water heaters, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Product Certificates: For each type of commercial, electric, domestic-water heater, from manufacturer.

C. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

D. Source quality-control reports.

E. Field quality-control reports.

F. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric, domestic-water heaters to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. 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.

B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

C. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects."

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric, domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including storage tank and supports.
b. Faulty operation of controls.

c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Periods: From date of Substantial Completion.

a. Commercial, Electric, Storage, Domestic-Water Heaters:

1) Storage Tank: Five years.
2) Controls and Other Components: Five years.

b. Compression Tanks: Five years.

1.10 MEASUREMENT AND PAYMENT

A. Measurement: Electric, Domestic Water Heaters shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Electric, Domestic Water Heaters shall include full compensation for furnishing all labor, materials, tools, equipment, supports, and incidentals, and for doing all Work involved in constructing electric, domestic water heaters complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 COMMERCIAL, ELECTRIC, DOMESTIC-WATER HEATERS

A. Commercial, Electric, Storage, Domestic-Water Heaters:

1. Standard: UL 1453.
2. Storage-Tank Construction: ASME-code, steel vertical arrangement.

a. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.

1) NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.

b. Pressure Rating: 150 psig.
c. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending lining material into tappings.

3. Factory-Installed Storage-Tank Appurtenances:

a. Anode Rod: Replaceable magnesium.
b. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
c. Insulation: Comply with ASHRAE/IESNA 90.1.
d. Jacket: Steel with enameled finish.
e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
f. Temperature Control: Adjustable thermostat.
g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.

h. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

4. Special Requirements: NSF 5 construction.

B. Commercial, Storage, Electric, Domestic-Water Heaters:

1. Standard: UL 174.
2. Storage-Tank Construction: Steel, vertical arrangement.

a. Tappings: ASME B1.20.1 pipe thread.
b. Pressure Rating: 150 psig.
c. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending lining material into tappings.

3. Factory-Installed Storage-Tank Appurtenances:

a. Anode Rod: Replaceable magnesium.
b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
c. Drain Valve: ASSE 1005.
d. Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2.
e. Jacket: Steel with enameled finish.
f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
g. Heating Elements: Two; electric, screw-in immersion type; wired for simultaneous operation unless otherwise indicated. Limited to 12 kW total.
h. Temperature Control: Adjustable thermostat.
i. Safety Control: High-temperature-limit cutoff device or system.
j. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.

4. Special Requirements: NSF 5 construction with legs for off-floor installation.

C. Capacity and Characteristics: Refer to plumbing drawings.

2.2 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Compression Tanks:

1. Description: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
2. Construction:

a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
b. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
c. Air-Charging Valve: Factory installed.

3. Capacity and Characteristics:

a. Working-Pressure Rating: 150 psig.
b. Capacity Acceptable: 4 gal. minimum.

B. Drain Pans: Stainless steel type 316 with raised edge. Comply with ANSI/CSA LC 3. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than NPS 3/4 with ASME B1.20.1 pipe threads or with ASME B1.20.7 garden-hose threads.

C. Combination Temperature-and-Pressure Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.

D. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of seismically supporting domestic-water heater and water.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect domestic-water heaters specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test commercial domestic-water heaters to minimum of one and one-half times pressure rating before shipment.

C. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

A. Install electric, domestic-water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."

B. Install commercial, electric, domestic-water heaters with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

C. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain or mop sink.

D. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for electric, domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."

E. Install thermometers on outlet piping of electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."

F. Fill electric, domestic-water heaters with water.

G. Charge domestic-water compression tanks with air.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to electric, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. 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.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

C. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial, electric, domestic-water heaters.

END OF SECTION 22 33 00

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SECTION 22 42 16.16

COMMERCIAL SINKS

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. Mop sinks.
2. Sink faucets.
3. Laminar-flow, faucet-spout outlets.
4. Supply fittings.
5. Waste fittings.
6. Supports.

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 sinks.
2. Include rated capacities, operating characteristics and furnished specialties and accessories.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For sinks to include in maintenance manuals.

1.6 MEASUREMENT AND PAYMENT

A. Measurement: Commercial Sinks shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Commercial Sinks shall include full compensation for furnishing all labor, materials, tools, equipment, supports, and incidentals, and for doing all Work involved in constructing commercial sinks complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 MOP SINK

A. Mop Sink: Stainless steel, Type 304, Gage 16, floor mounted.

1. Griffin Products Model UM-299 or Equal.
2. Fixture:

    a. Standard: ASME A112.19.3/CSA B45.4.
    b. Shape: Square.
    c. Style: With back and side wall guards.
    d. Bowl Size: 36 by 36 by 8 deep inches.
    e. Drain: Grid with NPS 3 outlet.
    f. Drain Location: Centered in compartment.
    g. Mounting: On floor and flush to wall.

3. Faucet: Refer "Sink Faucets" Article.

2.2 SINK FAUCETS

A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for faucet-spout materials that will be in contact with potable water.

B. Sink Faucets: Manual type, two-wrist blade-handle mixing valve.

1. Commercial, Solid-Brass Faucets.

    a. <u>American</u> Standard Model 8344.112.

2. Standard: ASME A112.18.1/CSA B125.1.
3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
4. Body Type: Widespread.
5. Body Material: Commercial, solid brass.
6. FinishChrome plated .
7. Maximum Flow Rate: 2.2 gpm.
8. Handle(s): Wrist blade, 4 inches.
9. Mounting Type: Back/wall, exposed.
10. Spout Type: Rigid, solid brass with pail hook and adjustable wall brace .
11. Vacuum Breaker: Required for hose outlet.
12. Spout Outlet: Hose thread according to ASME B1.20.7.

2.3 LAMINAR-FLOW, FAUCET-SPOUT OUTLETS

A. NSF Standard: Comply with NSF/ANSI 61 Annex 61, "Drinking Water System Components - Health Effects," for faucet-spout-outlet materials that will be in contact with potable water.

B. Description: Chrome-plated brass, faucet-spout outlet that produces non-aerating, laminar stream. Include external or internal thread that mates with faucet outlet for attachment to faucets where indicated and flow-rate range that includes flow of faucet.

2.4 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before sink installation.

B. Examine walls, floors, and counters for suitable conditions where sinks will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install sinks level and plumb according to roughing-in drawings.

B. Set floor-mounted sinks in leveling bed of cement grout.

C. Install water-supply piping with stop on each supply to each sink faucet.

1. Exception: Use ball or gate valves if supply stops are not specified with sink. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."
2. Install stops in locations where they can be easily reached for operation.

D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

E. Seal joints between sinks and counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

A. Connect sinks with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Operate and adjust sinks and controls. Replace damaged and malfunctioning sinks, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

A. After completing installation of sinks, inspect and repair damaged finishes.

B. Clean sinks, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed sinks and fittings.

D. Do not allow use of sinks for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 42 16.16

SECTION 22 45 00

EMERGENCY PLUMBING FIXTURES

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. Eye/face wash equipment.
   2. Water-tempering equipment.

1.3 DEFINITIONS

A. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.

B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.

C. Tepid: Moderately warm.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: Submit certificates of performance testing specified in "Source Quality Control" Article.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For emergency plumbing fixtures to include in operation and maintenance manuals.

1.7 QUALITY ASSURANCE

A. ANSI Standard: Comply with ANSI Z358.1, "Emergency Eyewash and Shower Equipment."

B. NSF Standard: Comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects," for fixture materials that will be in contact with potable water.

C. Regulatory Requirements: Comply with requirements in ICC/ANSI A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

1.8 MEASUREMENT AND PAYMENT

A. Measurement: Emergency Plumbing Fixtures shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Emergency Plumbing Fixtures shall include full compensation for furnishing all labor, materials, tools, equipment, supports, and incidentals, and for doing all Work involved in constructing emergency plumbing fixtures complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 EYE/FACE WASH EQUIPMENT

A. Accessible, Wall-Mounted, Plumbed, Eye/Face Wash Units:

1. Guardian Equipment G1724P or Equal.
2. Capacity: Not less than 3.0 gpm for at least 15 minutes.
3. Supply Piping: NPS 1/2 chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
4. Control-Valve Actuator: Paddle.
5. Spray-Head Assembly: Four receptor-mounted spray heads.
6. Receptor: ABS plastic bowl.
7. Mounting: Wall bracket.
8. Special Construction: Comply with ICC/ANSI A117.1.

2.2 WATER-TEMPERING EQUIPMENT

A. Hot- and Cold-Water, Water-Tempering Equipment:
1. Guardian Equipment or Equal
2. Description: Factory-fabricated equipment with thermostatic mixing valve.
    a. Thermostatic Mixing Valve: Designed to provide 85 deg F tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.
    b. Supply Connections: For hot and cold water.

c. Isolation ball valves on hot and cold supply and discharge tepid.

2.3 SOURCE QUALITY CONTROL

A. Certify performance of emergency plumbing fixtures by independent testing organization acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EMERGENCY PLUMBING FIXTURE INSTALLATION

A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.

B. Install fixtures level and plumb.

C. Fasten fixtures to substrate.

D. Install shutoff valves in water-supply piping to fixtures. Use ball valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Comply with requirements for valves specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."

E. Install dielectric fitting in supply piping to emergency equipment if piping and equipment connections are made of different metals. Comply with requirements for dielectric fittings specified in Section 221116 "Domestic Water Piping."

F. Install trap and waste piping on drain outlet of emergency equipment receptors that are indicated to be directly connected to drainage system. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."

G. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

H. Install thermometers in supply and outlet piping connections to water-tempering equipment.

3.3 CONNECTIONS

A. Connect hot- and cold-water-supply piping to hot- and cold-water, water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for hot- and cold-water piping specified in Section 221116 "Domestic Water Piping."

B. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary waste and vent piping. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."

C. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.4 IDENTIFICATION

A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Emergency plumbing fixtures and water-tempering equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust or replace fixture flow regulators for proper flow.

B. Adjust equipment temperature settings.

END OF SECTION 22 45 00

SECTION 23 05 13

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

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 general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

1.4 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section must be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Rotor: Random-wound, squirrel cage.

E. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

F. Temperature Rise: Match insulation rating.

G. Insulation: Class F.

H. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

I. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

C. Motors 1/20 HP and Smaller: Shaded-pole type.

D. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 05 13

SECTION 23 05 17

SLEEVES AND SLEEVE SEALS FOR HVAC 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. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, hot dipped galvanized, with plain ends and integral welded waterstop collar.

2.2 STACK-SLEEVE FITTINGS

A. Description: Manufactured, Dura-coated or Duco-coated cast-iron sleeve with integral cast flashing flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

A. Description:

1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
2. Designed to form a hydrostatic seal of 20-psig minimum.
3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
4. Pressure Plates: Stainless steel, Type 316.
5. Connecting Bolts and Nuts: Stainless steel, Type 316, of length required to secure pressure plates to sealing elements.

2.4 GROUT

A. Description: Nonshrink, recommended for interior and exterior sealing openings in nonfire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C 920, Type S, Grade NS, Class 25, use NT.

PART 3 - **EXECUTION**

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.

   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

3. Using grout or silicone sealant, seal space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 3 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using waterproof silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.

B. Fire-Resistance-Rated, Horizontal Assembly, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal-system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls Above Grade:

   a. Piping Smaller Than NPS 6: Steel pipe sleeves.

2. Concrete Slabs Above Grade:

   a. Piping Smaller Than NPS 6: Stack-sleeve fittings.

3. Interior Partitions:

   a. Piping Smaller Than NPS 6: Steel pipe sleeves.

END OF SECTION 23 05 17

SECTION 23 05 18

ESCUTCHEONS FOR HVAC 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. Escutcheons.
2. Floor plates.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 ESCUTCHEONS

A. One-Piece, Steel Type: With polished, chrome-plated finish and setscrew fastener.

B. One-Piece, Stainless-Steel Type: With polished stainless-steel finish.

C. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

D. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped steel with polished, chrome-plated finish and spring-clip fasteners.

E. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.

F. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed hinge; and spring-clip fasteners.

2.3 FLOOR PLATES

A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping:

   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
   b. Insulated Piping: One-piece stainless steel with polished stainless-steel finish.
   c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stainless steel with polished stainless-steel finish.
   d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stainless steel with polished stainless-steel finish.
   e. Bare Piping in Unfinished Service Spaces: One-piece steel with polished, chrome-plated finish.
   f. Bare Piping in Equipment Rooms: One-piece steel with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: Split floor plate.

3.2 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 23 05 18

SECTION 23 05 29

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

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. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Equipment supports.

B. Related Sections:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 230548 "Vibration and Seismic Controls for HVAC for vibration isolation devices.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.5 ACTION SUBMITTALS

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

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

1.8 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Hot dipped galvanized.

3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel hot-dipped galvanized.

B. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural hot-dipped galvanized carbon-steel shapes with MSS SP-58 hot-dipped galvanized carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:
1. Description: Shop- or field-fabricated hot-dipped galvanized pipe-support assembly for supporting multiple parallel pipes.
2. Standard: MFMA-4.
3. Channels: Continuous slotted hot-dipped galvanized steel channel with inturned lips.
4. Channel Nuts: Formed or stamped hot-dipped galvanized steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of hot-dipped galvanized carbon steel.
6. Metallic Coating: Hot-dipped galvanized.

2.4 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength and vapor barrier.

B. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

C. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

D. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type, stainless-steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

2.7 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.8 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:
1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.

G. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

J. Install lateral bracing with pipe hangers and supports to prevent swaying.

K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

L. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

N. Insulated Piping:

1. Attach clamps and spacers to piping.

    a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Shield Dimensions for Pipe: Not less than the following:

    a. NPS 1/4 to NPS 3-1/2 : 12 inches long and 0.048 inch thick.

3. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Section 099113 "Exterior Painting

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use hot-dipped galvanized carbon-steel pipe hangers and supports and metal framing systems and attachments for general service applications.

F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

G. Use padded hangers for piping that is subject to scratching.

H. Use thermal-hanger shield inserts for insulated piping and tubing.

I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
3. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.

J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.

K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.

c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

N. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

O. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

P. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 23 05 29

SECTION 23 05 48

VIBRATION AND SEISMIC CONTROLS FOR HVAC

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. Elastomeric isolation pads.
2. Restrained elastomeric isolation mounts.
3. Housed-restrained-spring isolators.
4. Pipe-riser resilient supports.
5. Elastomeric hangers.
6. Spring hangers.
7. Restraint channel bracings.
8. Restraint cables.
9. Seismic-restraint accessories.
10. Adhesive anchor bolts.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.

    a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.

b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators, seismic restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and seismic and wind forces required to select vibration isolators and seismic and wind restraints and for designing vibration isolation bases.

a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
4. Seismic- and Wind-Restraint Details:

a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data performed by an independent agency.

E. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

1.7 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:
1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
2. Size: Factory or field cut to match requirements of supported equipment.
3. Pad Material: Oil and water resistant with elastomeric properties.
4. Surface Pattern: Ribbed pattern.
5. Infused nonwoven cotton or synthetic fibers.
6. Load-bearing metal plates adhered to pads.

2.2 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:
   1. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

      a. Housing: Cast-ductile iron or welded steel.
      b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.3 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:
   1. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.

      a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
      b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.

   2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.4 PIPE-RISER RESILIENT SUPPORT

A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch- thick neoprene.

   1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
   2. Maximum Load Per Support: 500 psig on isolation material providing equal isolation in all directions.

2.5 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:
   1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
   2. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.6 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.7 SNUBBERS

A. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch air gap, and minimum 1/4-inch- thick resilient cushion.

2.8 RESTRAINT CHANNEL BRACINGS

A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.9 RESTRAINT CABLES

A. Restraint Cables: ASTM A 492 stainless-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.10 SEISMIC-RESTRAINT ACCESSORIES

A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

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

E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.11 ADHESIVE ANCHOR BOLTS

A. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with stainless steel for interior and exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic- and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033053 "Miscellaneous Cast-in-Place Concrete."

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

D. Equipment Restraints:

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

E. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction .

F. Install cables so they do not bend across edges of adjacent equipment or building structure.

G. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

H. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

I. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

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

K. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. dhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

END OF SECTION 23 05 48

SECTION 23 05 53

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

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. Equipment labels.
2. Pipe labels.
3. Duct labels.
4. Stencils.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Stainless steel, 0.025-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Letter Color: Black.
3. Background Color: White .
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
6. Fasteners: Stainless-steel rivets or self-tapping screws.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

2.3 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: White

C. Background Color: Blue.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/2 inch and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include duct size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

2.4 STENCILS

A. Stencils for Access Panels and Door Labels, Equipment Labels, and Similar Operational Instructions:

1. Lettering Size: Minimum letter height of 1/2 inch and proportionately larger lettering for greater viewing distances.
2. Stencil Material: Fiberboard.
3. Stencil Paint: Exterior, gloss, alkyd enamel. Paint may be in pressurized spray-can form.
4. Identification Paint: Exterior, alkyd enamel. Paint may be in pressurized spray-can form.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping Color Coding: Painting of piping is specified in Section 099600 "High-Performance Coatings."

B. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 25 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

D. Pipe Label Color Schedule:
1. Refrigerant Piping: Black letters on a safety-orange background.

3.5 DUCT LABEL INSTALLATION

A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.

B. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 25 feet in each space where ducts are exposed or concealed by removable ceiling system.

END OF SECTION 23 05 53

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

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. Balancing Air Systems:
   a. Constant-volume air systems.
2. Testing, Adjusting, and Balancing Equipment:
   a. Motors.
   b. Condensing units.
   c. Heat-transfer coils.
3. Testing, adjusting, and balancing existing systems and equipment.
4. Sound tests.
5. Vibration tests.
6. Duct leakage tests.
7. Control system verification.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. BAS: Building automation systems.

C. TAB: Testing, adjusting, and balancing.

D. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

1.4 PREINSTALLATION MEETINGS

A. TAB Conference: If requested by the Owner, conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.

1. Minimum Agenda Items:

a. The Contract Documents examination report.
b. The TAB plan.
c. Needs for coordination and cooperation of trades and subcontractors.
d. Proposed procedures for documentation and communication flow.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.

E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

F. Certified TAB reports.

G. Sample report forms.

H. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.6 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by AABC.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
2. TAB Technician: Employee of the TAB specialist and certified by AABC as a TAB technician.

B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

1.7 FIELD CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.8 MEASUREMENT AND PAYMENT

A. Measurement: Testing, Adjusting, And Balancing For HVAC shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Testing, Adjusting, And Balancing For HVAC shall include full compensation for furnishing all labor, materials, tools, equipment, supports, excavation and backfill, and incidentals, and for doing all Work involved in constructing testing, adjusting, and balancing for HVAC complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data including fan curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

F. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

G. Examine test reports specified in individual system and equipment Sections.

H. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

I. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

J. Examine operating safety interlocks and controls on HVAC equipment.

K. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:

   a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
   b. Duct systems are complete with terminals installed.
   c. Volume, smoke, and fire dampers are open and functional.
   d. Clean filters are installed.
   e. Fans are operating, free of vibration, and rotating in correct direction.
   f. Variable-frequency controllers' startup is complete and safeties are verified.
   g. Automatic temperature-control systems are operational.
   h. Ceilings are installed.
   i. Windows and doors are installed.
   j. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

2. Measure fan static pressures as follows:

   a. Measure static pressure directly at the fan outlet or through the flexible connection.
   b. Measure static pressure directly at the fan inlet or through the flexible connection.
   c. Measure static pressure across each component that makes up the air-handling system.
   d. Report artificial loading of filters at the time static pressures are measured.

3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.6 PROCEDURES FOR INDUCTION-UNIT SYSTEMS

A. Balance primary-air risers by measuring static pressure at the nozzles of the top and bottom units of each riser to determine which risers must be throttled. Adjust risers to indicated airflow within specified tolerances.

B. Adjust each induction unit.

C. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

2. Measure fan static pressures as follows:

    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.
    c. Measure static pressure across each component that makes up the air-handling system.
    d. Report artificial loading of filters at the time static pressures are measured.

3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

D. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

E. Balance airflow to each induction unit by measuring the nozzle pressure and comparing it to the manufacturer's published data for nozzle pressure versus cfm. Adjust the unit's inlet damper to achieve the required nozzle pressure for design cfm.

F. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.7 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.8 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record fan and motor operating data.

3.9 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.

3.10 SOUND TESTS

A. After the systems are balanced and construction is Substantially Complete, measure and record sound levels at 5 locations as designated by the Architect.

B. Instrumentation:

1. The sound-testing meter shall be a portable, general-purpose testing meter consisting of a microphone, processing unit, and readout.
2. The sound-testing meter shall be capable of showing fluctuations at minimum and maximum levels, and measuring the equivalent continuous sound pressure level (LEQ).
3. The sound-testing meter must be capable of using 1/3 octave band filters to measure mid-frequencies from 31.5 Hz to 8000 Hz.
4. The accuracy of the sound-testing meter shall be plus or minus one decibel.

C. Test Procedures:

1. Perform test at quietest background noise period. Note cause of unpreventable sound that affects test outcome.
2. Equipment should be operating at design values.
3. Calibrate the sound-testing meter prior to taking measurements.
4. Use a microphone suitable for the type of noise levels measured that is compatible with meter. Provide a windshield for outside or in-duct measurements.
5. Record a set of background measurements in dBA and sound pressure levels in the eight un-weighted octave bands 63 Hz to 8000 Hz (NC) with the equipment off.
6. Take sound readings in dBA and sound pressure levels in the eight un-weighted octave bands 63 Hz to 8000 Hz (NC) with the equipment operating.
7. Take readings no closer than 36 inches from a wall or from the operating equipment and approximately 60 inches from the floor, with the meter held or mounted on a tripod.
8. For outdoor measurements, move sound-testing meter slowly and scan area that has the most exposure to noise source being tested. Use A-weighted scale for this type of reading.

D. Reporting:

1. Report shall record the following:

   a. Location.
   b. System tested.
   c. dBA reading.
   d. Sound pressure level in each octave band with equipment on and off.

2. Plot sound pressure levels on NC worksheet with equipment on and off.

3.11 VIBRATION TESTS

A. After systems are balanced and construction is Substantially Complete, measure and record vibration levels on equipment having motor horsepower equal to or greater than 10.

B. Instrumentation:

1. Use portable, battery-operated, and microprocessor-controlled vibration meter with or without a built-in printer.
2. The meter shall automatically identify engineering units, filter bandwidth, amplitude, and frequency scale values.
3. The meter shall be able to measure machine vibration displacement in mils of deflection, velocity in inches per second, and acceleration in inches per second squared.
4. Verify calibration date is current for vibration meter before taking readings.

C. Test Procedures:

1. To ensure accurate readings, verify that accelerometer has a clean, flat surface and is mounted properly.
2. With the unit running, set up vibration meter in a safe, secure location. Connect transducer to meter with proper cables. Hold magnetic tip of transducer on top of the bearing, and measure unit in mils of deflection. Record measurement, then move transducer to the side of the bearing and record in mils of deflection. Record an axial reading in mils of deflection by holding nonmagnetic, pointed transducer tip on end of shaft.

3. Change vibration meter to velocity (inches per second) measurements. Repeat and record above measurements.
4. Record CPM or rpm.
5. Read each bearing on motor, fan, and pump as required. Track and record vibration levels from rotating component through casing to base.

D. Reporting:

1. Report shall record location and the system tested.
2. Include horizontal-vertical-axial measurements for tests.
3. Verify that vibration limits follow Specifications, or, if not specified, follow the General Machinery Vibration Severity Chart or Vibration Acceleration General Severity Chart from the AABC National Standards. Acceptable levels of vibration are normally "smooth" to "good."
4. Include in report General Machinery Vibration Severity Chart, with conditions plotted.

3.12 DUCT LEAKAGE TESTS

A. Witness the duct pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified tolerances.

C. Report deficiencies observed.

3.13 CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify temperature control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.14 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.15 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.16 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:
1. Fan curves.
2. Manufacturers' test data.
3. Field test reports prepared by system and equipment installers.
4. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.

13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Duct, outlet, and inlet sizes.
3. Balancing stations.
4. Position of balancing devices.

E. Apparatus-Coil Test Reports:

1. Coil Data:

    a. System identification.
    b. Location.
    c. Coil type.
    d. Number of rows.
    e. Fin spacing in fins per inch o.c.
    f. Make and model number.
    g. Face area in sq. ft..
    h. Tube size in NPS.
    i. Tube and fin materials.
    j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

    a. Airflow rate in cfm.
    b. Average face velocity in fpm.
    c. Air pressure drop in inches wg.
    d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
    e. Return-air, wet- and dry-bulb temperatures in deg F.
    f. Entering-air, wet- and dry-bulb temperatures in deg F.
    g. Leaving-air, wet- and dry-bulb temperatures in deg F.
    h. Refrigerant expansion valve and refrigerant types.
    i. Refrigerant suction pressure in psig.
    j. Refrigerant suction temperature in deg F.
    k. Inlet steam pressure in psig.

F. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

G. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F .
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft..
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

H. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.

e. Dates of calibration.

3.17 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Architect.

B. Architect shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If TAB work fails, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
3. If the second verification also fails, Architect may contact AABC Headquarters regarding the AABC National Performance Guaranty.

F. Prepare test and inspection reports.

3.18 ADDITIONAL TESTS

A. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 23 05 93

SECTION 23 07 19

HVAC PIPING INSULATION

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 insulating the following HVAC piping systems:

1. Condensate drain piping, indoors and outdoors.
2. Refrigerant suction and hot-gas piping, indoors and outdoors.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

1.9 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

C. PVC Jacket Adhesive: Compatible with PVC jacket.

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
   1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180 deg F.
   3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
   4. Color: White.

2.4 AGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
   1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
   2. Service Temperature Range: 0 to plus 180 deg F.
   3. Color: White.

2.5 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F.
   4. Color: Aluminum.

B. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F.
   4. Color: White.

2.6 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
   1. Adhesive: As recommended by jacket material manufacturer.
   2. Color: White.
   3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

      a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

C. Metal Jacket:

   1. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

      a. Factory cut and rolled to size.
      b. Material, finish, and thickness are indicated in field-applied jacket schedules.
      c. Moisture Barrier for Indoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
      d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
      e. Factory-Fabricated Fitting Covers:

         1) Same material, finish, and thickness as jacket.
         2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
         3) Tee covers.
         4) Flange and union covers.
         5) End caps.
         6) Beveled collars.
         7) Valve covers.
         8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

D. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with stucco-embossed aluminum-foil facing.

2.7 TAPES

A. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
   1. Width: 2 inches.
   2. Thickness: 6 mils.
   3. Adhesion: 64 ounces force/inch in width.
   4. Elongation: 500 percent.
   5. Tensile Strength: 18 lbf/inch in width.

B. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   1. Width: 2 inches.
   2. Thickness: 3.7 mils.
   3. Adhesion: 100 ounces force/inch in width.
   4. Elongation: 5 percent.
   5. Tensile Strength: 34 lbf/inch in width.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

   1. Verify that systems to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.
   3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

O. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.

3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
6. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
7. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
8. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

B. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.8 FINISHES

A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless-steel jackets.

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, three locations of threaded strainers, three locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.11 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:

1. All Pipe Sizes: Insulation shall be:
   a. Flexible Elastomeric: 1 inch thick.

B. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation shall be:
   a. Flexible Elastomeric: 1 inch thick.

C. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. All Pipe Sizes: Insulation shall be:

   a. Flexible Elastomeric: 1 inch thick.

3.12 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation shall be:
   a. Flexible Elastomeric: 2 inches thick.

B. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. All Pipe Sizes: Insulation shall be:

    a. Flexible Elastomeric: 2 inches thick.

3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:
  1. PVC, Color-Coded by System: 30 mils thick.

D. Piping, Exposed:
  1. PVC, Color-Coded by System: 30 mils thick.

3.14 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:
  1. Stainless Steel, Type 316, Smooth 2B Finish: 0.024 inch thick.

D. Piping, Exposed:
  1. Stainless Steel, Type 316, Smooth 2B Finishwith Z-Shaped Locking Seam: 0.024 inch thick.

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SECTION 23 09 23

DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

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. DDC system for monitoring and controlling of HVAC systems.
2. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.

B. Related Requirements:

1. Communications Cabling:
    a. Section 260523 "Control-Voltage Electrical Power Cables" for balanced twisted pair communications cable.
    b. Section 271513 "Communications Copper Horizontal Cabling" for balanced twisted pair communications cable.
    c. Section 271523 "Communications Optical Fiber Horizontal Cabling" for optical fiber communications cable.
2. Raceways:
    a. Section 260533 "Raceways and Boxes for Electrical Systems" for raceways for low-voltage control cable.
    b. Section 270528 "Pathways for Communications Systems" for raceways for balanced twisted pair cabling and optical fiber cable.
3. Section 260553 "Identification for Electrical Systems" for identification requirements for electrical components.
4. Section 270553 "Identification for Communications Systems" for identification requirements for communications components.

1.3 DEFINITIONS

A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. BACnet Specific Definitions:

1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data over and services over a network.
2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.
5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.

D. Binary: Two-state signal where a high signal level represents ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.

F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.

G. COV: Changes of value.

H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.

I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.

J. DOCSIS: Data-Over Cable Service Interface Specifications.

K. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

L. HLC: Heavy load conditions.

M. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

N. I/P: Current to pneumatic.

O. LAN: Local area network.

P. 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.

Q. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.

R. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

S. MTBF: Mean time between failures.

T. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.

U. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

V. Peer to Peer: Networking architecture that treats all network stations as equal partners.

W. POT: Portable operator's terminal.

X. PUE: Performance usage effectiveness.

Y. RAM: Random access memory.

Z. RF: Radio frequency.

AA. Router: Device connecting two or more networks at network layer.

BB. Server: Computer used to maintain system configuration, historical and programming database.

CC. TCP/IP: Transport control protocol/Internet protocol.

DD. UPS: Uninterruptible power supply.

EE. USB: Universal Serial Bus.

FF. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

GG. WLED: White light emitting diode.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site .

1.5 ACTION SUBMITTALS

A. Multiple Submissions:

1. If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.
2. Clearly identify each submittal requirement indicated and in which submission the information will be provided.
3. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.

B. Product Data: For each type of product include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
   a. Routers.
   b. Protocol analyzers.
   c. DDC controllers.
   d. Enclosures.
   e. Electrical power devices.
   f. UPS units.
   g. Accessories.
   h. Instruments.
   i. Control dampers and actuators.
   j. Control valves and actuators.

6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

C. Software Submittal:

1. Cross-referenced listing of software to be loaded on each operator workstation, server, gateway, and DDC controller.
2. Description and technical data of all software provided, and cross-referenced to products in which software will be installed.
3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
4. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
5. Listing and description of each engineering equation used with reference source.
6. Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
7. Description of operator interface to alphanumeric and graphic programming.
8. Description of each network communication protocol.

9. Description of system database, including all data included in database, database capacity and limitations to expand database.
10. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden and system throughout.
11. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

D. Shop Drawings:

1. General Requirements:

   a. Include cover drawing with Project name, location, Owner, Architect, Contractor and issue date with each Shop Drawings submission.
   b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.

2. Include plans, elevations, sections, and mounting details where applicable.
3. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Detail means of vibration isolation and show attachments to rotating equipment.
5. Plan Drawings indicating the following:

   a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork and piping.
   b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
   c. Each desktop workstation, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
   d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
   e. Network communication cable and raceway routing.
   f. Proposed routing of wiring, cabling, conduit, and tubing, coordinated with building services for review before installation.

6. Schematic drawings for each controlled HVAC system indicating the following:

   a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
   b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
   c. A graphic showing location of control I/O in proper relationship to HVAC system.
   d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
   e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
   f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
   g. Narrative sequence of operation.
   h. Graphic sequence of operation, showing all inputs and output logical blocks.

7. Control panel drawings indicating the following:

   a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
   b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
   c. Front, rear, and side elevations and nameplate legend.
   d. Unique drawing for each panel.

8. DDC system network riser diagram indicating the following:

   a. Each device connected to network with unique identification for each.
   b. Interconnection of each different network in DDC system.
   c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
   d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

9. DDC system electrical power riser diagram indicating the following:

   a. Each point of connection to field power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
   b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
   c. Each product requiring power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
   d. Power wiring type and size, race type, and size for each.

10. Monitoring and control signal diagrams indicating the following:

    a. Control signal cable and wiring between controllers and I/O.
    b. Point-to-point schematic wiring diagrams for each product.
    c. Control signal tubing to sensors, switches and transmitters.
    d. Process signal tubing to sensors, switches and transmitters.

11. Color graphics indicating the following:

    a. Itemized list of color graphic displays to be provided.
    b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
    c. Intended operator access between related hierarchical display screens.

E. System Description:

1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
3. System and product operation under each potential failure condition including, but not limited to, the following:

a. Loss of power.
b. Loss of network communication signal.
c. Loss of controller signals to inputs and outpoints.
d. Operator workstation failure.
e. Server failure.
f. Network failure
g. Controller failure.
h. Instrument failure.
i. Control damper actuator failure.

4. Complete bibliography of documentation and media to be delivered to Owner.
5. Description of testing plans and procedures.
6. Description of Owner training.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

a. Product installation location shown in relationship to room, duct, pipe and equipment.
b. Structural members to which products will be attached.
c. Wall-mounted instruments located in finished space showing relationship to light switches, fire-alarm devices and other installed devices.
d. Size and location of wall access panels for products installed behind walls and requiring access.

2. Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

a. Ceiling components.
b. Size and location of access panels for products installed above inaccessible ceiling assemblies and requiring access.
c. Items penetrating finished ceiling including the following:

1) Lighting fixtures.
2) Air outlets and inlets.
3) Speakers.
4) Access panels.
5) Temperature sensors and other DDC control system instruments.

B. Qualification Data:

1. Systems Provider Qualification Data:

a. Resume of project manager assigned to Project.
b. Resumes of application engineering staff assigned to Project.
c. Resumes of installation and programming technicians assigned to Project.
d. Resumes of service technicians assigned to Project.

e. Brief description of past project including physical address, floor area, number of floors, building system cooling and heating capacity and building's primary function.
f. Description of past project DDC system, noting similarities to Project scope and complexity indicated.
g. Names of staff assigned to past project that will also be assigned to execute work of this Project.
h. Owner contact information for past project including name, phone number, and e-mail address.
i. Contractor contact information for past project including name, phone number, and e-mail address.
j. Architect and Engineer contact information for past project including name, phone number, and e-mail address.

2. Manufacturer's qualification data.
3. Testing agency's qualifications data.

C. Welding certificates.

D. Product Certificates:

1. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135.

E. Product Test Reports: For each product that requires testing to be performed by a qualified testing agency.

F. Preconstruction Test Reports: For each separate test performed.

G. Source quality-control reports.

H. Field quality-control reports.

I. Sample Warranty: For manufacturer's warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
c. As-built versions of submittal Product Data.
d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.

f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
g. Engineering, installation, and maintenance manuals that explain how to:

1) Design and install new points, panels, and other hardware.
2) Perform preventive maintenance and calibration.
3) Debug hardware problems.
4) Repair or replace hardware.

h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
j. List of recommended spare parts with part numbers and suppliers.
k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
m. Licenses, guarantees, and warranty documents.
n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
o. Owner training materials.

1.8 MAINTENANCE MATERIAL SUBMITTALS

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

B. Include product manufacturers' recommended parts lists for proper product operation over **four**-year period following warranty period. Parts list shall be indicated for each year.

C. Furnish quantity indicated of matching product(s) in Project inventory for each unique size and type of following:

1. Network Controller: One per station.
2. Programmable Application Controller: One per station.
3. Application-Specific Controller: One per station.
4. Room Temperature Sensor and Transmitter: One per station .
5. General-Purpose Relay: One per station.
6. Multifunction Time-Delay Relay: One per station.
7. Latching Relay: One per station.
8. Current-Sensing Relay: One per station.
9. Combination On-Off Status Sensor and On-Off Relay: One per station.
10. Transformer: One per station.
11. DC Power Supply: One per station.
12. Supply of 20 percent spare optical fiber cable splice organizer cabinets for several re-terminations.

1.9 QUALITY ASSURANCE

A. DDC System Manufacturer Qualifications:

1. Nationally recognized manufacturer of DDC systems and products.
2. DDC systems with similar requirements to those indicated for a continuous period of **10** years within time of bid.
3. DDC systems and products that have been successfully tested and in use on at least **five** past projects.
4. Having complete published catalog literature, installation, operation and maintenance manuals for all products intended for use.
5. Having full-time in-house employees for the following:

   a. Product research and development.
   b. Product and application engineering.
   c. Product manufacturing, testing and quality control.
   d. Technical support for DDC system installation training, commissioning and troubleshooting of installations.
   e. Owner operator training.

B. DDC System Provider Qualifications:

1. Authorized representative of, and trained by, DDC system manufacturer.
2. Demonstrated past experience with installation of DDC system products being installed for period within **five** consecutive years before time of bid.
3. Demonstrated past experience on **five** projects of similar complexity, scope and value.
4. Each person assigned to Project shall have demonstrated past experience.
5. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
6. Service and maintenance staff assigned to support Project during warranty period.
7. Product parts inventory to support on-going DDC system operation for a period of not less than **5** years after Substantial Completion.
8. DDC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

C. Testing Agency Qualifications: Member company of NETA.

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

D. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
3. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
4. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

E. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.

    a. Install updates only after receiving Owner's written authorization.

3. Warranty service shall occur during normal business hours and commence within 24 hours of Owner's warranty service request.
4. Warranty Period: Two year(s) from date of Substantial Completion.

    a. For Gateway: Three-year parts and labor warranty for each.

PART 2 - PRODUCTS

2.1 DDC SYSTEM MANUFACTURERS

A. Automated Logic or Approved Equal

2.2 DDC SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.

1. DDC system shall consist of a high-speed, peer-to-peer network of distributed DDC controllers, other network devices, operator interfaces, and software.

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.

2.3 WEB ACCESS

A. DDC system shall be Web based.

1. Web-Based Access to DDC System:

    a. DDC system software shall be based on server thin-client architecture, designed around open standards of Web technology. DDC system server shall be accessed using a Web browser over DDC system network, using Owner's LAN, and remotely over Internet through Owner's LAN.
    b. Intent of thin-client architecture is to provide operators complete access to DDC system via a Web browser. No special software other than a Web browser shall be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
    c. Web access shall be password protected.

2.4 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

B. DDC System Speed:

1. Response Time of Connected I/O:

a. AI point values connected to DDC system shall be updated at least every two seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
b. BI point values connected to DDC system shall be updated at least every two seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
c. AO points connected to DDC system shall begin to respond to controller output commands within two second(s). Global commands shall also comply with this requirement.
d. BO point values connected to DDC system shall respond to controller output commands within two second(s). Global commands shall also comply with this requirement.

2. Display of Connected I/O:

a. Analog point COV connected to DDC system shall be updated and displayed at least every five seconds for use by operator.
b. Binary point COV connected to DDC system shall be updated and displayed at least every five > seconds for use by operator.
c. Alarms of analog and digital points connected to DDC system shall be displayed within 15 seconds of activation or change of state.
d. Graphic display refresh shall update within four seconds.
e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations shall not exceed graphic refresh rate indicated.

C. Network Bandwidth: Design each network of DDC system to include at least 30 percent available spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions.

D. DDC System Data Storage:

1. Include capability to archive not less than 60 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends and other information indicated.

E. DDC Data Access:

1. When logged into the system, operator shall be able to also interact with any DDC controller connected to DDC system as required for functional operation of DDC system.
2. System(s) shall be used for application configuration; for archiving, reporting and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.

F. Future Expandability:

1. DDC system size shall be expandable to an ultimate capacity of at least **two** times total I/O points indicated.
2. Additional DDC controllers, I/O and associated wiring shall be all that is needed to achieve ultimate capacity. Initial network infrastructure shall be designed and installed to support ultimate capacity.
3. Operator interfaces installed initially shall not require hardware and software additions and revisions for ultimate capacity.

G. Input Point Displayed Accuracy: Input point displayed values shall meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.

1. Level: Within 2 percent of reading.

2. Temperature, Dry Bulb:

   a. Air: Within 1 deg F .
   b. Space: Within 1 deg F.
   c. Temperature Difference: Within 0.25 deg F.
   d. Other Temperatures Not Indicated: Within 1 deg F.

3. Temperature, Wet Bulb:

   a. Air: Within 1 deg F.
   b. Space: Within 1 deg F.

H. Precision of I/O Reported Values: Values reported in database and displayed shall have following precision:

1. Current:

   a. Milliamperes: Nearest 1/100th of a milliampere.
   b. Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.

2. Energy:

   a. Electric Power:

      1) Rate (Watts): Nearest 1/10th of a watt through 1000 W.
      2) Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
      3) Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.

3. Temperature:

   a. Air, Ducts and Equipment: Nearest 1/10th of a degree.
   b. Outdoor: Nearest degree.
   c. Space: Nearest 1/10th of a degree.

I. Control Stability: Control variables indicated within the following limits:

1. Temperature, Dry Bulb:

   a. Air: Within 2 deg F.
   b. Space: Within 2 deg F.

2. Temperature, Wet Bulb:

   a. Air: Within 1 deg F.
   b. Space: Within 1 deg F.

J. Environmental Conditions for Controllers, Gateways, and Routers:

1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.

   a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.

2. Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:
   a. Indoors, Non-Filtered Ventilation: Type 2.
   b. Indoors, Heated and Air Conditioned: Type 1.
   c. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 3.
   d. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.
   e. Hazardous Locations: Explosion-proof rating for condition.

K. Environmental Conditions for Instruments and Actuators:

1. Instruments and actuators shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

   a. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by instrument and application.

2. Instruments, actuators and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments and actuators not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:

   a. Outdoors, Protected: Type 2.
   b. Outdoors, Unprotected: Type 4X.
   c. Indoors, Heated with Non-Filtered Ventilation: Type 2.
   d. Indoors, Heated and Air-conditioned: Type 1.

e. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 2.
f. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.
g. Hazardous Locations: Explosion-proof rating for condition.

L. DDC System Reliability:

1. Design, install and configure DDC controllers, gateways, routers, to yield a MTBF of at least 40,000 hours, based on a confidence level of at least 90 percent. MTBF value shall include any failure for any reason to any part of products indicated.
2. If required to comply with MTBF indicated, include DDC system and product redundancy to maintain DCC system, and associated systems and equipment that are being controlled, operational and under automatic control.
3. Critical systems and equipment that require a higher degree of DDC system redundancy than MTBF indicated shall be indicated on Drawings.

M. Electric Power Quality:

1. Power-Line Surges:

a. Protect DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.
b. Do not use fuses for surge protection.
c. Test protection in the normal mode and in the common mode, using the following two waveforms:

1) 10-by-1000-mic.sec. waveform with a peak voltage of 1500 V and a peak current of 60 A.
2) 8-by-20-mic.sec. waveform with a peak voltage of 1000 V and a peak current of 500 A.

2. Power Conditioning:

a. Protect DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner shall be as follows:

1) At 85 percent load, output voltage shall not deviate by more than plus or minus 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.
2) During load changes from zero to full load, output voltage shall not deviate by more than plus or minus 3 percent of nominal.
3) Accomplish full correction of load switching disturbances within five cycles, and 95 percent correction within two cycles of onset of disturbance.
4) Total harmonic distortion shall not exceed 3-1/2 percent at full load.

3. Ground Fault: Protect products from ground fault by providing suitable grounding. Products shall not fail due to ground fault condition.

N. Backup Power Source:

1. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.

O. UPS:

1. DDC system products powered by UPS units shall include the following:
   a. Gateways.
   b. DDC controllers.

P. Continuity of Operation after Electric Power Interruption:

1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.5 SYSTEM ARCHITECTURE

A. System architecture shall consist of no more than two levels of LANs.

1. Level one LAN shall connect network controllers.
2. Level one or Level two LAN shall connect programmable application controllers to other programmable application controllers, and to network controllers.
3. Level two LAN shall connect application-specific controllers to programmable application controllers and network controllers.
4. Level two LAN shall connect application-specific controllers to application-specific controllers.

B. Minimum Data Transfer and Communication Speed:

1. LAN Connecting Operator Workstations and Network Controllers: 100 Mbps.
2. LAN Connecting Programmable Application Controllers: 1000 kbps.
3. LAN Connecting Application-Specific Controllers: 115,000 bps.

C. DDC system shall consist of dedicated LANs that are not shared with other building systems and tenant data and communication networks.

D. System architecture shall be modular and have inherent ability to expand to not less than two times system size indicated with no impact to performance indicated.

E. System architecture shall perform modifications without having to remove and replace existing network equipment.

F. Number of LANs and associated communication shall be transparent to operator. All I/O points residing on any LAN shall be capable of global sharing between all system LANs.

G. System design shall eliminate dependence on any single device for system alarm reporting and control execution. Each controller shall operate independently by performing its' own control, alarm management and historical data collection.

2.6 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:
   1. Portable operator terminal with hardwired connection through LAN port.
   2. Mobile device and application with secured wireless connection through LAN router or cellular data service.
   3. Remote connection through web access.

B. Access to system, regardless of operator means used, shall be transparent to operator.

C. Network Ports: For hardwired connection of desktop or portable workstation. Network port shall be easily accessible, properly protected, clearly labeled, and installed at the following locations:

   1. Each Signal/Comm/IT rooms.

D. Portable Workstations:

   1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
   2. Able to communicate with any device located on any DDC system LAN.
   3. Portable workstation shall be able to communicate with any device connected to any system LAN regardless of point of physical connection to system.
   4. Monitor, program, schedule, adjust set points, and report capabilities of I/O connected anywhere in system.

E. POT:

   1. Connect DDC controller through a communications port local to controller.
   2. Able to communicate with any DDC system controller that is directly connected or with LAN.

F. Mobile Device:

   1. Connect to system through a wireless router connected to LAN and cellular data service.
   2. Able to communicate with any DDC controller connected to DDC system using a dedicated application and secure web access.

G. Telephone Communications:

   1. Through use of a standard modem, operator shall be able to communicate with any device connected to any system LAN.
   2. Have auto-dial and auto-answer communications to allow desktop and portable workstations and DDC controllers to communicate with remote workstations and remote DDC controllers via telephone lines.

      a. Portable Workstations:

         1) Operators shall be able to perform all control functions, report functions, and database generation and modification functions as if directly connected to system LAN.
         2) Have routines to automatically answer calls, and either file or display information sent remotely.

3) Communications taking place over telephone lines shall be completely transparent to operator.
4) Dial-up program shall maintain a user-definable cross-reference and associated telephone numbers so it is not required to remember or manually dial telephone numbers.

b. DDC Controllers:

1) Not have modems unless specifically indicated for a unique controller.
2) Controllers with modems shall automatically place calls to report critical alarms, or to upload trend and historical information for archiving.
3) Analyze and prioritize alarms to minimize initiation of calls.
4) Buffer noncritical alarms in memory and report them as a group of alarms, or until an operator manually requests an upload.
5) Make provisions for handling busy signals, no-answers, and incomplete data transfers.
6) Call default devices when communications cannot be established with primary devices.

H. Critical Alarm Reporting:

1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
2. DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.
3. DDC system shall notify recipients by any or all means, including e-mail, text message and prerecorded phone message to mobile and landline phone numbers.

I. Simultaneous Operator Use: Capable of accommodating up to **five** simultaneous operators that are accessing DDC system through any one of operator interfaces indicated.

2.7 NETWORKS

A. Acceptable networks for connecting workstations, mobile devices, and network controllers include the following:
1. IEEE 8802-3, Ethernet.

B. Acceptable networks for connecting programmable application controllers include the following:
1. IEEE 8802-3, Ethernet.

C. Acceptable networks for connecting application-specific controllers include the following:
1. IEEE 8802-3, Ethernet.

2.8 NETWORK COMMUNICATION PROTOCOL

A. Network communication protocol(s) used throughout entire DDC system shall be open to Owner and available to other companies for use in making future modifications to DDC system.

B. ASHRAE 135 Protocol:

1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.

2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

2.9 PORTABLE OPERATOR TERMINAL

A. Description: Handheld device with integral keypad or touch screen operator interface.

B. Display: Multiple lines of text display for use in operator interaction with DDC system.

C. Cable: Flexible coiling cable, at least 36 inches long, with a plug-in jack for connection to DDC controllers, network ports or instruments with an integral LAN port. As an alternative to hardwired connection, POT shall be accessible to DDC controllers through a wireless network connection.

D. POT shall be powered through network connection.

E. Connection of POT to DDC system shall not interrupt or interfere with normal network operation in any way, prevent alarms from being transmitted, or preclude central initiated commands and system modification.

F. POT shall give operator the ability to do the following:

1. Display and monitor BI point status.
2. Change BO point set point (on or off, open or closed).
3. Display and monitor analog point values.
4. Change analog control set points.
5. Command a setting of AO point.
6. Display and monitor I/O point in alarm.
7. Add a new or delete an existing I/O point.
8. Enable and disable I/O points, initiators, and programs.
9. Display and change time and date.
10. Display and change time schedules.
11. Display and change run-time counters and run-time limits.
12. Display and change time and event initiation.
13. Display and change control application and DDC parameters.
14. Display and change programmable offset values.
15. Access DDC controller initialization routines and diagnostics.

2.10 SYSTEM SOFTWARE

A. System Software Minimum Requirements:

1. Real-time multitasking and multiuser **64-**bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
2. Operating system shall be capable of operating DOS and Microsoft Windows applications.
3. Database management software shall manage all data on an integrated and non-redundant basis. Additions and deletions to database shall be without detriment to existing data. Include cross

linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.

4. Network communications software shall manage and control multiple network communications to provide exchange of global information and execution of global programs.
5. Operator interface software shall include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
6. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:

1. Minimize operator training through use of English language prorating and English language point identification.
2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
3. Operator sign-off shall be a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
4. Automatic sign-off period shall be programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Operator sign-on and sign-off activity shall be recorded and sent to printer.
6. Security Access:

   a. Operator access to DDC system shall be under password control.
   b. An alphanumeric password shall be field assignable to each operator.
   c. Operators shall be able to access DDC system by entry of proper password.
   d. Operator password shall be same regardless of which computer or other interface means is used.
   e. Additions or changes made to passwords shall be updated automatically.
   f. Each operator shall be assigned an access level to restrict access to data and functions the operator is cable of performing.
   g. Software shall have at least five access levels.
   h. Each menu item shall be assigned an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
   i. Display menu items to operator with those capable of access highlighted. Menu and operator access level assignments shall be online programmable and under password control.

7. Data Segregation:

   a. Include data segregation for control of specific data routed to a workstation, to an operator or to a specific output device, such as a printer.
   b. Include at least **32** segregation groups.
   c. Segregation groups shall be selectable such as "fire points," "fire points on second floor," "space temperature points," "HVAC points," and so on.
   d. Points shall be assignable to multiple segregation groups. Display and output of data to printer or monitor shall occur where there is a match of operator or peripheral segregation group assignment and point segregations.
   e. Alarms shall be displayed and printed at each peripheral to which segregation allows, but only those operators assigned to peripheral and having proper authorization level will be allowed to acknowledge alarms.
   f. Operators and peripherals shall be assignable to multiple segregation groups and all assignments are to be online programmable and under password control.

8. Operators shall be able to perform commands including, but not limited to, the following:

    a. Start or stop selected equipment.
    b. Adjust set points.
    c. Add, modify, and delete time programming.
    d. Enable and disable process execution.
    e. Lock and unlock alarm reporting for each point.
    f. Enable and disable totalization for each point.
    g. Enable and disable trending for each point.
    h. Override control loop set points.
    i. Enter temporary override schedules.
    j. Define holiday schedules.
    k. Change time and date.
    l. Enter and modify analog alarm limits.
    m. Enter and modify analog warning limits.
    n. View limits.
    o. Enable and disable demand limiting.
    p. Enable and disable duty cycle.
    q. Display logic programming for each control sequence.

9. Reporting:

    a. Generated automatically and manually.
    b. Sent to displays, printers and disk files.
    c. Types of Reporting:

        1) General listing of points.
        2) List points currently in alarm.
        3) List of off-line points.
        4) List points currently in override status.
        5) List of disabled points.
        6) List points currently locked out.
        7) List of items defined in a "Follow-Up" file.
        8) List weekly schedules.
        9) List holiday programming.
        10) List of limits and deadbands.

10. Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

C. Graphic Interface Software:

1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface shall use a pointing device with pull-down or penetrating menus, color and animation to facilitate operator understanding of system.
3. Include at least 10 levels of graphic penetration with the hierarchy operator assignable.
4. Descriptors for graphics, points, alarms and such shall be modified through operator's workstation under password control.

5. Graphic displays shall be online user definable and modifiable using the hardware and software provided.
6. Data to be displayed within a graphic shall be assignable regardless of physical hardware address, communication or point type.
7. Graphics are to be online programmable and under password control.
8. Points may be assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
9. Graphics shall also contain software points.
10. Penetration within a graphic hierarchy shall display each graphic name as graphics are selected to facilitate operator understanding.
11. Back-trace feature shall permit operator to move upward in the hierarchy using a pointing device. Back trace shall show all previous penetration levels. Include operator with option of showing each graphic full screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
12. Display operator accessed data on the monitor.
13. Operator shall select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Defined and linked graphic below that selection shall then be displayed.
14. Include operator with means to directly access graphics without going through penetration path.
15. Dynamic data shall be assignable to graphics.
16. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
17. Use color, rotation, or other highly visible means, to denote status and alarm states. Color shall be variable for each class of points, as chosen by operator.
18. Points shall be dynamic with operator adjustable update rates on a per point basis from one second to over a minute.
19. For operators with appropriate privilege, points shall be commanded directly from display using pointing device.

    a. For an analog command point such as set point, current conditions and limits shall be displayed and operator can position new set point using pointing device.
    b. For a digital command point such as valve position, valve shall show its current state such as open or closed and operator could select alternative position using pointing device.
    c. Keyboard equivalent shall be available for those operators with that preference.

20. Operator shall be able to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot and other information on other quadrants on screen. This feature shall allow real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.
21. Help Features:

    a. On-line context-sensitive help utility to facilitate operator training and understanding.
    b. Bridge to further explanation of selected keywords. Document shall contain text and graphics to clarify system operation.

        1) If help feature does not have ability to bridge on keywords for more information, a complete set of user manuals shall be provided in an indexed word-processing program, which shall run concurrently with operating system software.

    c. Available for Every Menu Item:

        1) Index items for each system menu item.

22. Graphic generation software shall allow operator to add, modify, or delete system graphic displays.

    a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols.
    b. Graphic development package shall use a pointing device in conjunction with a drawing program to allow operator to perform the following:

        1) Define background screens.
        2) Define connecting lines and curves.
        3) Locate, orient and size descriptive text.
        4) Define and display colors for all elements.
        5) Establish correlation between symbols or text and associated system points or other displays.

D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:

    a. Room layouts with room identification and name.
    b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
    c. Location and identification of each hardware point being controlled or monitored by DDC system.

3. Control schematic for each of following, including a graphic system schematic representation, similar to that indicated on Drawings, with point identification, set point and dynamic value indication, sequence of operation and control logic diagram.
4. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.
5. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, gateways and other network devices.

E. Customizing Software:

1. Software to modify and tailor DDC system to specific and unique requirements of equipment installed, to programs implemented and to staffing and operational practices planned.
2. Online modification of DDC system configuration, program parameters, and database using menu selection and keyboard entry of data into preformatted display templates.
3. As a minimum, include the following modification capability:

    a. Operator assignment shall include designation of operator passwords, access levels, point segregation and auto sign-off.
    b. Peripheral assignment capability shall include assignment of segregation groups and operators to consoles and printers, designation of backup workstations and printers, designation of workstation header points and enabling and disabling of print-out of operator changes.
    c. System configuration and diagnostic capability shall include communications and peripheral port assignments, DDC controller assignments to network, DDC controller

enable and disable, assignment of command trace to points and application programs and initiation of diagnostics.

d. System text addition and change capability shall include English or native language descriptors for points, segregation groups and access levels and action messages for alarms, run time and trouble condition.
e. Time and schedule change capability shall include time and date set, time and occupancy schedules, exception and holiday schedules and daylight savings time schedules.
f. Point related change capability shall include the following:

   1) System and point enable and disable.
   2) Run-time enable and disable.
   3) Assignment of points to segregation groups, calibration tables, lockout, and run time and to a fixed I/O value.
   4) Assignment of alarm and warning limits.

g. Application program change capability shall include the following:

   1) Enable and disable of software programs.
   2) Programming changes.
   3) Assignment of comfort limits, global points, time and event initiators, time and event schedules and enable and disable time and event programs.

4. Software shall allow operator to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Additions and modifications shall be online programmable using operator workstation, downloaded to other network devices and entered into their databases. After verification of point additions and associated program operation, database shall be uploaded and recorded on hard drive and disk for archived record.
5. Include high-level language programming software capability for implementation of custom DDC programs. Software shall include a compiler, linker, and up- and down-load capability.
6. Include a library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences. Also include, as a minimum, the following:

   a. Proportional control (P).
   b. Proportional plus integral (PI).
   c. Proportional plus integral plus derivative (PID).
   d. Adaptive and intelligent self-learning control.

      1) Algorithm shall monitor loop response to output corrections and adjust loop response characteristics according to time constant changes imposed.
      2) Algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of system dynamics so that on system shut down and restart, learning process starts from where it left off.

7. Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time of day, highest select AO, lowest select AO, analog controlled digital output, analog control AO, and digitally controlled AO.
8. Logic operators such as "And," "Or," "Not," and others that are part of a standard set available with a high-level language.
9. Arithmetic operators such as "Add," "Subtract," "Multiply," "Divide," and others that are part of a standard set available with a high-level language.
10. Relational operators such as "Equal To," "Not Equal To," "Less Than," "Greater Than," and others that are part of a standard set available with a high-level language.

F. Alarm Handling Software:

1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers, gateways and other network devices.
2. Include first in, first out handling of alarms according to alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.
3. Alarm handling shall be active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
4. Alarms display shall include the following:

    a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
    b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
    c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
    d. Include extended message capability to allow assignment and printing of extended action messages. Capability shall be operator programmable and assignable on a per point basis.

5. Alarms shall be directed to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.
6. Send e-mail alarm messages to designated operators.
7. Send e-mail, page, text and voice messages to designated operators for critical alarms.
8. Alarms shall be categorized and processed by class.

    a. Class 1:

        1) Associated with fire, security and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
        2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.
        3) All conditions shall cause an audible sound and shall require individual acknowledgment to silence audible sound.

    b. Class 2:

        1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
        2) Acknowledgement may be through a multiple alarm acknowledgment.

    c. Class 3:

        1) General alarms; printed, displayed and placed in unacknowledged alarm buffer queues.
        2) Each new alarm received shall cause an audible sound. Audible sound shall be silenced by "acknowledging" alarm or by pressing a "silence" key.
        3) Acknowledgement of queued alarms shall be either on an individual basis or through a multiple alarm acknowledgement.
        4) Alarms returning to normal condition shall be printed and not cause an audible sound or require acknowledgment.

    d. Class 4:

        1) Routine maintenance or other types of warning alarms.

2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.

9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator shall be able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.
10. To ensure that no alarm records are lost, it shall be possible to assign a backup printer to accept alarms in case of failure of primary printer.

G. Reports and Logs:

1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
2. Each report shall be definable as to data content, format, interval and date.
3. Report data shall be sampled and stored on DDC controller, within storage limits of DDC controller.
4. Operator shall be able to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
5. Reports and logs shall be readily printed and set to be printed either on operator command or at a specific time each day.

H. Standard Reports: Standard DDC system reports shall be provided and operator shall be able to customize reports later.

1. All I/O: With current status and values.
2. Alarm: All current alarms, except those in alarm lockout.
3. Disabled I/O: All I/O points that are disabled.
4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
6. Logs:

   a. Alarm history.
   b. System messages.
   c. System events.
   d. Trends.

I. Custom Reports: Operator shall be able to easily define any system data into a daily, weekly, monthly, or annual report. Reports shall be time and date stamped and shall contain a report title.

J. HVAC Equipment Reports: Prepare Project-specific reports.

K. Standard Trends:

1. Trend all I/O point present values, set points, and other parameters indicated for trending.
2. Trends shall be associated into groups, and a trend report shall be set up for each group.
3. Trends shall be stored within DDC controller and uploaded to hard drives automatically on reaching **75** of DDC controller buffer limit, or by operator request, or by archiving time schedule.
4. Preset trend intervals for each I/O point after review with Owner.
5. Trend intervals shall be operator selectable from 10 seconds up to 60 minutes. Minimum number of consecutive trend values stored at one time shall be 100 per variable.
6. When drive storage memory is full, most recent data shall overwrite oldest data.
7. Archived and real-time trend data shall be available for viewing numerically and graphically by operators.

L. Custom Trends: Operator shall be able to define a custom trend log for any I/O point in DDC system.

1. Each trend shall include interval, start time, and stop time.
2. Data shall be sampled and stored on DDC controller, within storage limits of DDC controller.
3. Data shall be retrievable for use in spreadsheets and standard database programs.

M. Programming Software:

1. Include programming software to execute sequences of operation indicated.
2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
3. Programming software shall be as follows:

   a. Graphic Based: Programming shall use a library of function blocks made from preprogrammed code designed for DDC control systems.

      1) Function blocks shall be assembled with interconnection lines that represent to control sequence in a flowchart.
      2) Programming tools shall be viewable in real time to show present values and logical results of each function block.

   b. Menu Based: Programming shall be done by entering parameters, definitions, conditions, requirements and constraints.
   c. Line by Line and Text Based: Programming shall declare variable types such as local, global, real, integer, and so on, at the beginning of the program. Use descriptive comments frequently to describe programming code.

4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

2.11 ASHRAE 135 GATEWAYS

A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable.

B. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment, only when specifically requested and approved by Owner.

C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.

D. Gateway Minimum Requirements:

1. Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.
2. Write to all writeable object properties on non-BACnet network from BACnet network and vice versa where applicable.
3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet and vice versa.

4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs according to ASHRAE 135.
5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
6. Backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

2.12 DDC CONTROLLERS

A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.

B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.

C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.

D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.

E. Environment Requirements:

1. Controller hardware shall be suitable for the anticipated ambient conditions.
2. Controllers located in conditioned space shall be rated for operation at 32 to 120 deg F.
3. Controllers located outdoors shall be rated for operation at 40 to 150 deg F.

F. Power and Noise Immunity:

1. Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.
2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within36 inches of enclosure.

G. DDC Controller Spare Processing Capacity:

1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:

   a. Network Controllers: 70 percent.
   b. Programmable Application Controllers: Not less than 80 percent.
   c. Application-Specific Controllers: Not less than 80.

2. Memory shall support DDC controller's operating system and database and shall include the following:

   a. Monitoring and control.
   b. Energy management, operation and optimization applications.
   c. Alarm management.
   d. Historical trend data of all connected I/O points.
   e. Maintenance applications.
   f. Operator interfaces.

g. Monitoring of manual overrides.

H. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:

1. Network Controllers:
   a. Minimum Spare I/O Points per Controller:

      1) AIs: Three.
      2) AOs: Three.
      3) BIs: Five .
      4) BOs: Five.

2. Programmable Application Controllers:
   a. Minimum Spare I/O Points per Controller:

      1) AIs: Three.
      2) AOs: Three.
      3) BIs: Five.
      4) BOs: Five.

3. Application-Specific Controllers:
   a. Minimum Spare I/O Points per Controller:

      1) AIs: Two.
      2) AOs: Two.
      3) BIs: Two.
      4) BOs: Two.

I. Maintenance and Support: Include the following features to facilitate maintenance and support:

1. Mount microprocessor components on circuit cards for ease of removal and replacement.
2. Means to quickly and easily disconnect controller from network.
3. Means to quickly and easily access connect to field test equipment.
4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

J. Input and Output Point Interface:

1. Hardwired input and output points shall connect to network, programmable application and application-specific controllers.
2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.
4. AIs:

   a. AIs shall include monitoring of low-voltage (zero- to 10-V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
   b. AIs shall be compatible with, and field configurable to, sensor and transmitters installed.
   c. Controller AIs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 12 bits or better to comply with accuracy requirements indicated.
   d. Signal conditioning including transient rejection shall be provided for each AI.
   e. Capable of being individually calibrated for zero and span.

f. Incorporate common-mode noise rejection of at least 50 dB from zero to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.

5. AOs:

a. Controller AOs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 12 bits or better to comply with accuracy requirements indicated.
b. Output signals shall have a range of 4 to 20 mA dc as required to include proper control of output device.
c. Capable of being individually calibrated for zero and span.
d. AOs shall not exhibit a drift of greater than 0.4 percent of range per year.

6. BIs:

a. Controller BIs shall accept contact closures and shall ignore transients of less than 5-ms duration.
b. Isolation and protection against an applied steady-state voltage of up to 180-V ac peak.
c. BIs shall include a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against effects of contact bounce and noise.
d. BIs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.
e. Pulse accumulation input points shall comply with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Buffer shall be provided to totalize pulses. Pulse accumulator shall accept rates of at least 20 pulses per second. The totalized value shall be reset to zero on operator's command.

7. BOs:

a. Controller BOs shall include relay contact closures or triac outputs for momentary and maintained operation of output devices.

1) Relay contact closures shall have a minimum duration of 0.1 second. Relays shall include at least 180 V of isolation. Electromagnetic interference suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be 1 A at 24-V ac.
2) Triac outputs shall include at least 180 V of isolation. Minimum contact rating shall be 1 A at 24-V ac.

b. BOs shall include for two-state operation or a pulsed low-voltage signal for pulse-width modulation control.
c. BOs shall be selectable for either normally open or normally closed operation.
d. Include tristate outputs (two coordinated BOs) for control of three-point floating-type electronic actuators without feedback.

2.13 NETWORK CONTROLLERS

A. General Network Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. System shall consist of one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.

3. Controller shall have enough memory to support its operating system, database, and programming requirements.
4. Data shall be shared between networked controllers and other network devices.
5. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Controllers shall have a real-time clock.
7. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
8. Controllers shall be fully programmable.

B. Communication:

1. Network controllers shall communicate with other devices on DDC system Level one network.
2. Network controller also shall perform routing if connected to a network of programmable application and application-specific controllers.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation or mobile device.
2. Local Keypad and Display:

   a. Equip controller with local keypad and digital display for interrogating and editing data.
   b. Use of keypad and display shall require security password.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.14 PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. Controller shall have enough memory to support its operating system, database, and programming requirements.
3. Data shall be shared between networked controllers and other network devices.
4. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Controllers shall have a real-time clock.
6. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
7. Controllers shall be fully programmable.

B. Communication:

1. Programmable application controllers shall communicate with other devices on network.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation or mobile device.
2. Local Keypad and Display:

   a. Equip controller with local keypad and digital display for interrogating and editing data.
   b. Use of keypad and display shall require security password.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.15 APPLICATION-SPECIFIC CONTROLLERS

A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.

1. Capable of standalone operation and shall continue to include control functions without being connected to network.
2. Data shall be shared between networked controllers and other network devices.

B. Communication: Application-specific controllers shall communicate with other application-specific controller and devices on network, and to programmable application and network controllers.

C. Operator Interface: Controller shall be equipped with a service communications port for connection to a portable operator's workstation.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.16 CONTROLLER SOFTWARE

A. General Controller Software Requirements:

1. Software applications shall reside and operate in controllers. Editing of applications shall occur at operator workstations.
2. I/O points shall be identified by up to 30-character point name and up to 16-character point descriptor. Same names shall be used at operator workstations.
3. Control functions shall be executed within controllers using DDC algorithms.
4. Controllers shall be configured to use stored default values to ensure fail-safe operation. Default values shall be used when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:

1. Operator access shall be secured using individual security passwords and user names.
2. Passwords shall restrict operator to points, applications, and system functions as assigned by system manager.
3. Operator log-on and log-off attempts shall be recorded.
4. System shall protect itself from unauthorized use by automatically logging off after last keystroke. The delay time shall be operator-definable.

C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule shall consist of the following:

1. Weekly Schedule:

    a. Include separate schedules for each day of week.
    b. Each schedule should include the capability for start, stop, optimal start, optimal stop, and night economizer.
    c. Each schedule may consist of up to 10 events.
    d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.

2. Exception Schedules:

    a. Include ability for operator to designate any day of the year as an exception schedule.
    b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.

3. Holiday Schedules:

    a. Include capability for operator to define up to 99 special or holiday schedules.
    b. Schedules may be placed on scheduling calendar and will be repeated each year.
    c. Operator shall be able to define length of each holiday period.

D. System Coordination:

1. Include standard application for proper coordination of equipment.
2. Application shall include operator with a method of grouping together equipment based on function and location.
3. Group may then be used for scheduling and other applications.

E. Binary Alarms:

1. Each binary point shall be set to alarm based on operator-specified state.
2. Include capability to automatically and manually disable alarming.

F. Analog Alarms:

1. Each analog object shall have both high and low alarm limits.
2. Alarming shall be able to be automatically and manually disabled.

G. Alarm Reporting:

1. Operator shall be able to determine action to be taken in event of an alarm.
2. Alarms shall be routed to appropriate operator workstations based on time and other conditions.
3. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.

H. Remote Communication:

1. System shall have ability to dial out in the event of an alarm.

I. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.

J. Control Loops:

1. Support any of the following control loops, as applicable to control required:

   a. Two-position (on/off, open/close, slow/fast) control.
   b. Proportional control.
   c. Proportional plus integral (PI) control.
   d. Proportional plus integral plus derivative (PID) control.

      1) Include PID algorithms with direct or reverse action and anti-windup.
      2) Algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs.
      3) Controlled variable, set point, and PID gains shall be operator-selectable.

   e. Adaptive (automatic tuning).

K. Staggered Start: Application shall prevent all controlled equipment from simultaneously restarting after a power outage. Order which equipment (or groups of equipment) is started, along with the time delay between starts, shall be operator-selectable.

L. Anti-Short Cycling:

1. BO points shall be protected from short cycling.
2. Feature shall allow minimum on-time and off-time to be selected.

M. On and Off Control with Differential:

1. Include an algorithm that allows a BO to be cycled based on a controlled variable and set point.
2. Algorithm shall be direct- or reverse-acting and incorporate an adjustable differential.

N. Run-Time Totalization:

1. Include software to totalize run-times for all BI and BO points.
2. A high run-time alarm shall be assigned, if required, by operator.

2.17 ENCLOSURES

A. General Enclosure Requirements:

1. House each controller and associated control accessories in a enclosure. Enclosure shall serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies and transformers.
2. Do not house more than one controller in a single enclosure.
3. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
4. Equip doors of enclosures housing controllers and components with analog or digital displays with windows to allow visual observation of displays without opening enclosure door.
5. Individual wall-mounted single-door enclosures shall not exceed 36 inches wide and 48 inches high.
6. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall.
7. Supply each enclosure with a complete set of as-built schematics, tubing, and wiring diagrams and product literature located in a pocket on inside of door. For enclosures with windows, include pocket on bottom of enclosure.

B. Internal Arrangement:

1. Internal layout of enclosure shall group and protect pneumatic, electric, and electronic components associated with a controller, but not an integral part of controller.
2. Arrange layout to group similar products together.
3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
4. Factory or shop install products, tubing, cabling and wiring complying with requirements and standards indicated.
5. Terminate field cable and wire using heavy-duty terminal blocks.
6. Include spare terminals, equal to not less than 20 percent of used terminals.
7. Include spade lugs for stranded cable and wire.
8. Install a maximum of two wires on each side of a terminal.
9. Include enclosure field power supply with a toggle-type switch located at entrance inside enclosure to disconnect power.
10. Include enclosure with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.
11. Mount products within enclosure on removable internal panel(s).
12. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). The nameplates shall have at least 1/4-inch- high lettering.
13. Route tubing cable and wire located inside enclosure within a raceway with a continuous removable cover.
14. Label each end of cable, wire and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
15. Size enclosure internal panel to include at least 25 percent spare area on face of panel.

C. Wall-Mounted, NEMA 250, Type 1:

1. Enclosure shall be NRTL listed according to UL 50 or UL 50E.
2. Construct enclosure of steel, not less than:

   a. Enclosure size less than 24 in.: 0.067 in. thick.
   b. Enclosure size 24 in. and larger: 0.067 in. thick.

3. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

   a. Exterior color shall be ANSI 61 gray.
   b. Interior color shall be ANSI 61 gray.

4. Hinged door full size of front face of enclosure and supported using:

   a. Enclosures sizes less than 36 in. tall: Multiple butt hinges.
   b. Enclosures sizes 36 in. tall and larger: Continuous piano hinges.

5. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.

   a. Size less than 24 in.: Solid or Perforated steel, 0.053 in. thick.
   b. Size 24 in. and larger: Solid steel, 0.093 in. thick.

6. Internal panel mounting hardware, grounding hardware and sealing washers.
7. Grounding stud on enclosure body.
8. Thermoplastic pocket on inside of door for record Drawings and Product Data.

D. Wall Mounted NEMA 250, Types 4 and 12:
1. Enclosure shall be NRTL listed according to UL 508A.
2. Seam and joints are continuously welded and ground smooth.
3. Where recessed enclosures are indicated, include enclosures with face flange for flush mounting.
4. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
5. Single-door enclosure sizes up to 60 inches tall by 36 inches wide.
6. Double-door enclosure sizes up to 36 inches tall by 60 inches wide.
7. Construct enclosure of steel, not less than the following:

   a. Size Less Than 24 Inches: 0.067 inch thick.
   b. Size 24 Inches and Larger: 0.067 inch thick.

8. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

   a. Exterior color shall be ANSI 61 gray.
   b. Interior color shall be ANSI 61 gray.

9. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.

   a. Sizes through 24 Inches Tall: Two hinges.
   b. Sizes between 24 Inches through 48 Inches Tall: Three hinges.
   c. Sizes Larger 48 Inches Tall: Four hinges.

10. Double-door enclosures with overlapping door design to include unobstructed full-width access.

    a. Single-door enclosures 48 inches and taller, and all double-door enclosures, with three-point (top, middle and bottom) latch system.

11. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Size Less Than 24 Inches: Solid or perforated steel, 0.053 inch thick.
    b. Size 24 Inches and Larger: Solid steel, 0.093 inch thick.

12. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
13. Grounding stud on enclosure body.
14. Thermoplastic pocket on inside of door for record Drawings and Product Data.

E. Wall-Mounted, NEMA 250, Type 4X SS:
1. Enclosure shall be NRTL listed according to UL 508A.
2. Seam and joints are continuously welded and ground smooth.
3. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
4. Construct enclosure of Type 316L stainless steel, not less than the following:

    a. Size Less Than 24 Inches: 0.053 inch thick.
    b. Size 24 Inches and Larger: 0.067 inch thick.

5. Outside body and door of enclosure with brushed No. 4 finish.

6. Corner-formed door, full size of enclosure face, supported using continuous piano hinge full length of door.
7. Doors fitted with three-point (top, middle, and bottom) latch system with single, heavy-duty, liquid-tight Type 316 stainless-steel handle with integral locking mechanism.
8. Removable internal panel shall be 0.093-inch solid steel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
9. Internal panel mounting studs and hardware, grounding hardware, and sealing washers.
10. Install corrosion-resistant polyester vent drain in a stainless-steel sleeve at the bottom of enclosure.
11. Include enclosure with stainless-steel mounting brackets.

F. Accessories:

1. Framed Fixed Window Kit for NEMA 250, Types 4, 4X, and 12 Enclosures:

    a. 0.25-inch- thick, scratch-resistant acrylic or polycarbonate window mounted in a metal frame matching adjacent door material.
    b. Enclosure types, except NEMA 250 Type 1, shall have a continuous gasket material around perimeter of window and frame to provide watertight seal.
    c. Window kit shall be factory or shop installed before shipment to Project.

2. Frameless Fixed Window Kit for NEMA 250, Type 1 Enclosures:

    a. 0.125-inch- thick, polycarbonate window mounted in enclosure door material.
    b. Window attached to door with screw fasteners and continuous strip of high-strength double-sided tape around window perimeter.
    c. Window kit shall be factory or shop installed before shipment to Project.

3. Frame Fixed or Hinged Window Kit for NEMA 250, Types 1 and 12 Enclosures:

    a. 0.25-inch- thick, scratch-resistant acrylic or polycarbonate window mounted in a metal frame matching adjacent door material.

b. Enclosure types, except NEMA 250 Type 1, shall have a continuous gasket material around perimeter of window and frame to provide watertight seal.
c. Window kit shall be factory or shop installed before shipment to Project.

4. Bar handle with keyed cylinder lock set.

2.18 RELAYS

A. General-Purpose Relays:
1. Relays shall be heavy duty and rated for at least 10 A at 250-V ac and 60 Hz.
2. Relays shall be either double pole double throw (DPDT) or three-pole double throw, depending on the control application.
3. Use a plug-in-style relay with an eight-pin octal plug for DPDT relays and an 11-pin octal plug for three-pole double-throw relays.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
6. Relays shall have LED indication and a manual reset and push-to-test button.
7. Performance:

a. Mechanical Life: At least 10 million cycles.
b. Electrical Life: At least 100,000 cycles at rated load.
c. Pickup Time: 15 ms or less.
d. Dropout Time: 10 ms or less.
e. Pull-in Voltage: 85 percent of rated voltage.
f. Dropout Voltage: 50 percent of nominal rated voltage.
g. Power Consumption: 2 VA.
h. Ambient Operating Temperatures: Minus 40 to 115 deg F .

8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

B. Multifunction Time-Delay Relays:
1. Relays shall be continuous duty and rated for at least 10 A at 240-V ac and 60 Hz.
2. Relays shall be DPDT relay with up to eight programmable functions to provide on/off delay, interval and recycle timing functions.
3. Use a plug-in-style relay with either an 8- or 11-pin octal plug.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a dust-tight cover.
6. Include knob and dial scale for setting delay time.
7. Performance:

a. Mechanical Life: At least 10 million cycles.
b. Electrical Life: At least 100,000 cycles at rated load.
c. Timing Ranges: Multiple ranges from 0.1 seconds to 100 minutes.
d. Repeatability: Within 2 percent.
e. Recycle Time: 45 ms.
f. Minimum Pulse Width Control: 50 ms.
g. Power Consumption: 5 VA or less at 120-V ac.
h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

C. Latching Relays:
1. Relays shall be continuous duty and rated for at least 10 A at 250-V ac and 60 Hz.
2. Relays shall be either DPDT or three-pole double throw, depending on the control application.
3. Use a plug-in-style relay with a multibladed plug.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
6. Performance:

   a. Mechanical Life: At least 10 million cycles.
   b. Electrical Life: At least 100,000 cycles at rated load.
   c. Pickup Time: 15 ms or less.
   d. Dropout Time: 10 ms or less.
   e. Pull-in Voltage: 85 percent of rated voltage.
   f. Dropout Voltage: 50 percent of nominal rated voltage.
   g. Power Consumption: 2 VA.
   h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

7. Equip relays with coil transient suppression to limit transients to non-damaging levels.
8. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
9. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

D. Current Sensing Relay:
1. Monitors ac current.
2. Independent adjustable controls for pickup and dropout current.
3. Energized when supply voltage is present and current is above pickup setting.
4. De-energizes when monitored current is below dropout current.
5. Dropout current is adjustable from 50 to 95 percent of pickup current.
6. Include a current transformer, if required for application.
7. House current sensing relay and current transformer in its own enclosure. Use NEMA 250, Type 12 enclosure for indoors and NEMA 250, Type 4 for outdoors.

E. Combination On-Off Status Sensor and On-Off Relay:
1. Description:

   a. On-off control and status indication in a single device.
   b. LED status indication of activated relay and current trigger.
   c. Closed-Open-Auto override switch located on the load side of the relay.

2. Performance:

   a. Ambient Temperature: Minus 30 to 140 deg F.
   b. Voltage Rating: Single-phase loads rated for 300-V ac. Three-phase loads rated for 600-V ac.

3. Status Indication:

a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.
b. Current Sensor Range: As required by application.
c. Current Set Point: Adjustable.
d. Current Sensor Output:
1) Analog, 4 to 20 mA, loop powered.

4. Relay: Single-pole double-throw, continuous-duty coil; rated for 10-million mechanical cycles.
5. Enclosure: NEMA 250, Type 1 enclosure.

2.19 ELECTRICAL POWER DEVICES

A. Transformers:

1. Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.
2. Transformer shall be at least 100 VA.
3. Transformer shall have both primary and secondary fuses.

B. Power-Line Conditioner:
1. General Power-Line Conditioner Requirements:

a. Design to ensure maximum reliability, serviceability and performance.
b. Overall function of the power-line conditioner is to receive raw, polluted electrical power and purify it for use by electronic equipment. The power-line conditioner shall provide isolated, regulated, transient and noise-free sinusoidal power to loads served.

2. Standards: NRTL listed per UL 1012.
3. Performance:

a. Single phase, continuous, 100 percent duty rated KVA/KW capacity. Design to supply power for linear or nonlinear, high crest factor, resistive and reactive loads.
b. Automatically regulate output voltage to within 2 percent or better with input voltage fluctuations of plus 10 to minus 20 percent of nominal when system is loaded 100 percent. Use Variable Range Regulation to obtain improved line voltage regulation when operating under less than full load conditions.

1) At 75 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 35 percent of nominal.
2) At 50 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 40 percent of nominal.
3) At 25 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 45 percent of nominal.

c. With input voltage distortion of up to 40 percent, limit the output voltage sine wave to a maximum harmonic content of 5 percent.
d. Automatically regulate output voltage to within 2.5 percent when load (resistive) changes from zero percent to 100 percent to zero percent.
e. Output voltage returns to 95 percent of nominal level within two cycles and to 100 percent within three cycles when the output is taken from no load to full resistive load or vice-versa. Recovery from partial resistive load changes is corrected in a shorter period of time.

f. K Factor: 30, designed to operate with nonlinear, non-sinusoidal, high crest factor loads without overheating.
g. Input power factor within 0.95 approaching unity with load power factor as poor as 0.6.
h. Attenuate load-generated odd current harmonics 23 dB at the input.
i. Electrically isolate the primary from the secondary. Meet isolation criteria as defined in NFPA 70, Article 250-5D.
j. Lighting and Surge Protection: Compares to UL 1449 rating of 330 V when subjected to Category B3 (6000 V/3000 A) combination waveform as established by IEEE C62.41.
k. Common-mode noise attenuation of 140 dB.
l. Transverse-mode noise attenuation of 120 dB.
m. With loss of input power for up to 16.6 ms, the output sine wave remains at usable ac voltage levels.
n. Reliability of 200,000 hours' MTBF.
o. At full load, when measured at 1-m distance, audible noise is not to exceed 54 dB.
p. Approximately 92 percent efficient at full load.

4. Transformer Construction:

a. Ferroresonant, dry type, convection cooled, 600V class. Transformer windings of Class H (220 deg C) insulated copper.
b. Use a Class H installation system throughout with operating temperatures not to exceed 150 deg C over a 40-deg C ambient temperature.
c. Configure transformer primary for multi-input voltage. Include input terminals for source conductors and ground.
d. Manufacture transformer core using M-6 grade, grain-oriented, stress-relieved transformer steel.
e. Configure transformer secondary in a 240/120-V split with a 208-V tap or straight 120 V, depending on power output size.
f. Electrically isolate the transformer secondary windings from the primary windings. Bond neutral conductor to cabinet enclosure and output neutral terminal.
g. Include interface terminals for output power hot, neutral and ground conductors.
h. Label leads, wires and terminals to correspond with circuit wiring diagram.
i. Vacuum impregnate transformer with epoxy resin.

5. Cabinet Construction:

a. Design for panel or floor mounting.
b. NEMA 250, Type 1, general-purpose, indoor enclosure.
c. Manufacture the cabinet from heavy gauge steel complying with UL 50.
d. Include a textured baked-on paint finish.

C. Transient Voltage Suppression and High-Frequency Noise Filter Unit:
1. The maximum continuous operating voltage shall be at least 125 percent.
2. The operating frequency range shall be 47 to 63 Hz.
3. Protection modes according to NEMA LS-1.
4. The rated single-pulse surge current capacity, for each mode of protection, shall be no less than the following:

a. Line to Neutral: 45,000 A.
b. Neutral to Ground: 45,000 A.
c. Line to Ground: 45,000 A.
d. Per Phase: 90,000 A.

5. Clamping voltages shall be in compliance with test and evaluation procedures defined in NEMA LS-1. Maximum clamping voltage shall be as follows:

    a. Line to Neutral: 360 V.
    b. Line to Ground: 360 V.
    c. Neutral to Ground: 360 V.

6. Electromagnetic interference and RF interference noise rejection or attenuation values shall comply with test and evaluation procedures defined in NEMA LS-1.

    a. Line to Neutral:

        1) 100 kHz: 42 dB.
        2) 1 MHz: 25 dB.
        3) 10 MHz: 21 dB.
        4) 100 MHz: 36 dB.

    b. Line to Ground:

        1) 100 kHz: 16 dB.
        2) 1 MHz: 55 dB.
        3) 10 MHz: 81 dB.
        4) 100 MHz: 80 dB.

7. Unit shall have LED status indicator that extinguishes to indicate a failure.
8. Unit shall be listed by an NRTL as a transient voltage surge suppressor per UL 1449, and as an electromagnetic interference filter per UL 1283.
9. Unit shall not generate any appreciable magnetic field.
10. Unit shall not generate an audible noise.

D. DC Power Supply:
1. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.
2. Enclose circuitry in a housing.
3. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.
4. Performance:

    a. Output voltage nominally 25-V dc within 5 percent.
    b. Output current up to 100 mA.
    c. Input voltage nominally 120-V ac, 60 Hz.
    d. Load regulation within 0.5 percent from zero- to 100-mA load.
    e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
    f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

2.20 CONTROL WIRE AND CABLE

A. Wire: Single conductor control wiring above 24 V.

1. Wire size shall be at least No. 16 AWG.
2. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch lay.

3. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.
4. Conductor colors shall be black (hot), white (neutral), and green (ground).
5. Furnish wire on spools.

B. Single Twisted Shielded Instrumentation Cable above 24 V:

1. Wire size shall be a minimum No. 18 AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
4. Shielding shall be 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 600-V, 90-deg C rating and shall be Type TC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

C. Single Twisted Shielded Instrumentation Cable 24 V and Less:

1. Wire size shall be a minimum No. 18 AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
4. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be Type PLTC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

1. Cable shall be balanced twisted pair.

2.21 RACEWAYS

A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

B. Comply with requirements in Section 270528 "Pathways for Communications Systems" for raceways for balanced twisted pair cables and optical fiber cables.

2.22 OPTICAL FIBER CABLE AND CONNECTORS

A. Comply with requirements in Section 271323 "Communications Optical Fiber Backbone Cabling" for optical fiber backbone cabling and connectors.

B. Comply with requirements in Section 271523 "Communications Optical Fiber Horizontal Cabling" for optical fiber horizontal cabling and connectors.

2.23 ACCESSORIES

A. Instrument Enclosures:
1. Include instrument enclosure for secondary protection to comply with requirements indicated in "Performance Requirements" Article.
2. NRTL listed and labeled to UL 50.
3. Sized to include at least 25 percent spare area on subpanel.
4. Instrument(s) mounted within enclosure on internal subpanel(s).
5. Enclosure face with engraved, laminated phenolic nameplate for each instrument within enclosure.
6. Enclosures housing pneumatic instruments shall include main pressure gage and a branch pressure gage for each pneumatic device, installed inside.
7. Enclosures housing multiple instruments shall route tubing and wiring within enclosure in a raceway having a continuous removable cover.
8. Enclosures larger than 12 inches shall have a hinged full-size face cover.
9. Equip enclosure with lock and common key.

2.24 IDENTIFICATION

A. Control Equipment, Instruments, and Control Devices:

1. Laminated acrylic or melamine plastic sign bearing unique identification.

   a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.

2. Letter size shall be as follows:
   a. DDC Controllers: Minimum of1.0 inch high.
   b. Gateways: Minimum of 1.0 inch high.
   c. Repeaters: Minimum of 1.0 inch high.
   d. Enclosures: Minimum of 1.0 inch high.
   e. Electrical Power Devices: Minimum of 0. 5 inch high.
   f. Accessories: Minimum of 0. 5 inch high.
   g. Instruments: Minimum of 0. 5 inch high.
   h. Control Damper Actuators: Minimum of 0. 5 inch high.

3. Legend shall consist of white lettering on black background.
4. Laminated acrylic or melamine plastic sign shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded black with contrasting white center exposed by engraving through outer layer and shall be fastened with drive pins.
5. Instruments, control devices and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require additional identification.

B. Raceway and Boxes:

1. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
2. Paint cover plates on junction boxes and conduit same color as the tape banding for conduits. After painting, label cover plate "HVAC Controls," using an engraved phenolic tag.

C. Equipment Warning Labels:

1. Self-adhesive label with pressure-sensitive adhesive back and peel-off protective jacket.
2. Lettering size shall be at least 14-point type with white lettering on red background.
3. Warning label shall read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
4. Lettering shall be enclosed in a white line border. Edge of label shall extend at least 0. 5 inch beyond white border.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

   1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for products to verify actual locations of connections before installation.

   1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
   2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

A. Communication Interface to Equipment with Integral Controls:

   1. DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.
   2. Equipment to Be Connected:
      a. Split-System Air-Conditioners specified in Section 23 81 26 "Split-System Air-Conditioners."

B. Communication Interface to Other Building Systems:

   1. DDC system shall have a communication interface with systems having a communication interface.
   2. Systems to Be Connected:
      a. Elevators specified in Section 142400 "Hydraulic Elevators."

3.3 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.

B. Deliver the following to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.

1. DDC control dampers, which are specified in Section 230923.12 "DDC Control Dampers."
2. Airflow sensors and switches, which are specified in Section 230923.14 "Flow Instruments."

3.4 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to a seismic force.

D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

F. Firestop Penetrations Made in Fire-Rated Assemblies: Comply with requirements in Section 078413 "Penetration Firestopping."

G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 079200 "Joint Sealants."

H. Welding Requirements:

1. Restrict welding and burning to supports and bracing.
2. No equipment shall be cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
3. Welding, where approved, shall be by inert-gas electric arc process and shall be performed by qualified welders according to applicable welding codes.
4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.

I. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

J. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

3.5 POT INSTALLATION

A. Install two portable operator terminal(s).

B. Turn over POTs to Owner at Substantial Completion.

C. Install software on each POT and verify that software functions properly.

3.6 ROUTER INSTALLATION

A. Install routers if required for DDC system communication interface requirements indicated.

1. Install router(s) required to suit indicated requirements.

B. Test router to verify that communication interface functions properly.

3.7 CONTROLLER INSTALLATION

A. Install controllers in enclosures to comply with indicated requirements.

B. Connect controllers to field power supply and to UPS units where indicated.

C. Install controller with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Network Controllers:

1. Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Top of controller shall be within 72 inches of finished floor.

F. Installation of Programmable Application Controllers:

1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Top of controller shall be within 72 inches of finished floor.

G. Application-Specific Controllers:

1. Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.

2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.8 INSTALLATION OF WIRELESS ROUTERS FOR OPERATOR INTERFACE

A. Install wireless routers to achieve optimum performance and best possible coverage.

B. Mount wireless routers in a protected location that is within 60 inches of floor and easily accessible by operators.

C. Connect wireless routers to field power supply and to UPS units if network controllers are powered through UPS units.

D. Install wireless router with latest version of applicable software and configure wireless router with WPA2 security and password protection. Create access password with not less than 12 characters consisting of letters and numbers and at least one special character. Document password in operations and maintenance manuals for reference by operators.

E. Test and adjust wireless routers for proper operation with portable workstation and other wireless devices intended for use by operators.

3.9 ENCLOSURES INSTALLATION

A. Install the following items in enclosures, to comply with indicated requirements:

1. Gateways.
2. Routers.
3. Controllers.
4. Electrical power devices.
5. UPS units.
6. Relays.
7. Accessories.
8. Instruments.
9. Actuators

B. Attach wall-mounted enclosures to wall using the following types of steel struts:

1. For NEMA 250, Type 1 Enclosures: Use corrosion-resistant-coated steel strut and hardware.
2. For NEMA 250, Type 4X Enclosures and Enclosures Located Outdoors: Use stainless-steel strut and hardware.
3. Install plastic caps on exposed cut edges of strut.

C. Align top or bottom of adjacent enclosures of like size.

D. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireway used for application shall have protection equal to NEMA 250 rating of connected enclosures.

3.10 ELECTRIC POWER CONNECTIONS

A. Connect electrical power to DDC system products requiring electrical power connections.

B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.

C. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.

D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.

E. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

3.11 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification products and installation.

B. Install laminated acrylic or melamine plastic signs with unique identification on face for each of the following:
1. Gateway.
2. Router.
3. Protocol analyzer.
4. DDC controller.
5. Enclosure.
6. Electrical power device.
7. UPS unit.
8. Accessory.

C. Install unique instrument identification on face of each instrument connected to a DDC controller.

D. Install unique identification on face of each control damper actuator connected to a DDC controller.

E. Where product is installed above accessible tile ceiling, also install matching identification on face of ceiling grid located directly below.

F. Where product is installed above an inaccessible ceiling, also install identification on face of access door directly below.

G. Warning Labels and Signs:

1. Shall be permanently attached to equipment that can be automatically started by DDC control system.
2. Shall be located in highly visible location near power service entry points.

3.12 NETWORK INSTALLATION

A. Install balanced twisted pair cable when connecting between the following network devices located in same building:
   1. Network controllers.

B. Install balanced twisted pair or copper cable (as required by equipment) when connecting between the following:

   1. Gateways.
   2. Gateways and network controllers or programmable application controllers.
   3. Routers.
   4. Routers and network controllers or programmable application controllers.
   5. Network controllers and programmable application controllers.
   6. Programmable application controllers.
   7. Programmable application controllers and application-specific controllers.
   8. Application-specific controllers.

C. Install cable in continuous raceway.

   1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

3.13 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

B. ASHRAE 135 Networks:

   1. MAC Address:

      a. Every network device shall have an assigned and documented MAC address unique to its network.
      b. Ethernet Networks: Document MAC address assigned at its creation.
      c. ARCNET or MS/TP networks: Assign from 00 to 64.

   2. Network Numbering:

      a. Assign unique numbers to each new network.
      b. Provide ability for changing network number through device switches or operator interface.
      c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.

   3. Device Object Identifier Property Number:

      a. Assign unique device object identifier property numbers or device instances for each device network.
      b. Provide for future modification of device instance number by device switches or operator interface.
      c. LAN shall support up to 4,194,302 unique devices.

   4. Device Object Name Property Text:

      a. Device object name property field shall support 32 minimum printable characters.

b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.

1) Example 1: Device object name for device controlling boiler plant at Building 1000 would be "HW System B1000."
2) Example 2: Device object name for a VAV terminal unit controller could be "VAV unit 102".

5. Object Name Property Text for Other Than Device Objects:

a. Object name property field shall support 32 minimum printable characters.
b. Assign object name properties with plain-English names descriptive of application.

1) Example 1: "Zone 1 Temperature."
2) Example 2 "Fan Start and Stop."

6. Object Identifier Property Number for Other Than Device Objects:

a. Assign object identifier property numbers according to [**Drawings**] [**or**] [**tables**] indicated.
b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented and be unique for like object types within device.

3.14 CONTROL WIRE, CABLE AND RACEWAYS INSTALLATION

A. Comply with NECA 1.

B. Wire and Cable Installation:

1. Comply with installation requirements in Section 260523 "Control-Voltage Electrical Power Cables."
2. Comply with installation requirements in Section 271313 "Communications Copper Backbone Cabling."
3. Comply with installation requirements in Section 271513 "Communications Copper Horizontal Cabling."
4. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.

a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.

5. Terminate wiring in a junction box.

a. Clamp cable over jacket in junction box.
b. Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.

6. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
7. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.
8. Use shielded cable to transmitters.

9. Use shielded cable to temperature sensors.
10. Perform continuity and meager testing on wire and cable after installation.

C. Conduit Installation:

1. Comply with Section "260533 "Raceways and Boxes for Electrical Systems" for control-voltage conductors.
2. Comply with Section 270528 "Pathways for Communications Systems" for balanced twisted pair cabling and optical fiber installation.

3.15 OPTICAL FIBER CABLE SYSTEM INSTALLATION

A. Comply with installation requirements in Section 271323 "Communications Optical Fiber Backbone Cabling."

B. Comply with installation requirements in Section 271523 "Communications Optical Fiber Horizontal Cabling."

3.16 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Testing:

1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.
2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.
3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.
4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by DDC system manufacturer. Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.
5. Test Equipment: Use an optical fiber time domain reflectometer for testing of length and optical connectivity.

6. Test Results: Record test results and submit copy of test results for Project record.

3.17 DDC SYSTEM I/O CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. Control Damper Checkout:

1. For pneumatic dampers, verify that pressure gages are provided in each air line to damper actuator and positioner.
2. Verify that control dampers are installed correctly for flow direction.
3. Verify that proper blade alignment, either parallel or opposed, has been provided.
4. Verify that damper frame attachment is properly secured and sealed.
5. Verify that damper actuator and linkage attachment is secure.
6. Verify that actuator wiring is complete, enclosed and connected to correct power source.
7. Verify that damper blade travel is unobstructed.

E. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments:

    a. Verify sensing element type and proper material.
    b. Verify length and insertion.

3.18 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.

D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.

E. Provide diagnostic and test equipment for calibration and adjustment.

F. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

G. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

H. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

I. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

J. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

K. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact making or breaking.

L. Control Dampers:

1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

N. Switches: Calibrate switches to make or break contact at set points indicated.

O. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.19 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

1. Verify voltage, phase and hertz.
2. Verify that protection from power surges is installed and functioning.
3. Verify that ground fault protection is installed.
4. If applicable, verify if connected to UPS unit.
5. If applicable, verify if connected to a backup power source.
6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.20 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify operation is stable and accurate.
4. Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:

    a. Upper quarter of range.
    b. Lower quarter of range.
    c. At midpoint of range.

8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller and at field instrument shall match.
10. Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

3.21 DDC SYSTEM VALIDATION TESTS

A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.

B. After approval of Test Plan, execute all tests and procedures indicated in plan.

C. After testing is complete, submit completed test checklist.

D. Pretest Checklist: Submit the following list with items checked off once verified:

1. Detailed explanation for any items that are not completed or verified.
2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
3. HVAC equipment motors operate below full-load amperage ratings.
4. Required DDC system components, wiring, and accessories are installed.
5. Installed DDC system architecture matches approved Drawings.
6. Control electric power circuits operate at proper voltage and are free from faults.
7. Required surge protection is installed.
8. DDC system network communications function properly, including uploading and downloading programming changes.
9. Using BACnet protocol analyzer, verify that communications are error free.
10. Each controller's programming is backed up.
11. Equipment, products, tubing, wiring cable and conduits are properly labeled.
12. All I/O points are programmed into controllers.
13. Testing, adjusting and balancing work affecting controls is complete.
14. Dampers and actuators zero and span adjustments are set properly.
15. Each control damper and actuator goes to failed position on loss of power.
16. Meter, sensor and transmitter readings are accurate and calibrated.
17. Control loops are tuned for smooth and stable operation.
18. View trend data where applicable.
19. Each controller works properly in standalone mode.
20. Safety controls and devices function properly.
21. Interfaces with fire-alarm system function properly.
22. Electrical interlocks function properly.
23. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphic are created.
24. Record Drawings are completed.

E. Test Plan:

1. Prepare and submit a validation test plan including test procedures for performance validation tests.
2. Test plan shall address all specified functions of DDC system and sequences of operation.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include a test checklist to be used to check and initial that each test has been successfully completed.
6. Submit test plan documentation 10 business days before start of tests.

F. Validation Test:

1. Verify operating performance of each I/O point in DDC system.

    a. Verify analog I/O points at operating value.
    b. Make adjustments to out-of-tolerance I/O points.

        1) Identify I/O points for future reference.

2) Simulate abnormal conditions to demonstrate proper function of safety devices.
3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.

2. Simulate conditions to demonstrate proper sequence of control.
3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4. After 24 Hours following Initial Validation Test:

   a. Re-check I/O points that required corrections during initial test.
   b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.

5. After 24 Hours of Second Validation Test:

   a. Re-check I/O points that required corrections during second test.
   b. Continue validation testing until I/O point is normal on two consecutive tests.

6. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
7. After validation testing is complete, prepare and submit a report indicating all I/O points that required correction and how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

G. DDC System Response Time Test:

1. Simulate HLC.

   a. Heavy load shall be an occurrence of 50 percent of total connected binary COV, one-half of which represent an "alarm" condition, and 50 percent of total connected analog COV, one-half of which represent an "alarm" condition, that are initiated simultaneously on a one-time basis.

2. Initiate 10 successive occurrences of HLC and measure response time to typical alarms and status changes.
3. Measure with a timer having at least 0.1-second resolution and 0.01 percent accuracy.
4. Purpose of test is to demonstrate DDC system, as follows:

   a. Reaction to COV and alarm conditions during HLC.
   b. Ability to update DDC system database during HLC.

5. Passing test is contingent on the following:

   a. Alarm reporting at printer beginning no more than two seconds after the initiation (time zero) of HLC.
   b. All alarms, both binary and analog, are reported and printed; none are lost.
   c. Compliance with response times specified.

6. Prepare and submit a report documenting HLC tested and results of test including time stamp and print out of all alarms.

H. DDC System Network Bandwidth Test:

1. Test network bandwidth usage on all DDC system networks to demonstrate bandwidth usage under DDC system normal operating conditions and under simulated HLC.
2. To pass, none of DDC system networks shall use more than 70 percent of available bandwidth under normal and HLC operation.

3.22 FINAL REVIEW

A. Submit written request to Architect and Construction Manager when DDC system is ready for final review. Written request shall state the following:

  1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
  2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
  3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
  4. DDC system is complete and ready for final review.

B. Review by Architect shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Should more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.

E. Prepare and submit closeout submittals and begin procedures indicated in "Extended Operation Test" Article when no deficiencies are reported.

F. A part of DDC system final review shall include a demonstration to parties participating in final review.

  1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
  2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
  3. Demonstration shall include, but not be limited to, the following:

     a. Accuracy and calibration of 10 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
     b. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to 10 I/O points shall be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.
     c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.
     d. Operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.

e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.

f. Trends, summaries, logs and reports set-up for Project.

g. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.

h. Software's ability to communicate with controllers, operator workstations, uploading and downloading of control programs.

i. Software's ability to edit control programs off-line.

j. Data entry to show Project-specific customizing capability including parameter changes.

k. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.

l. Execution of digital and analog commands in graphic mode.

m. Spreadsheet and curve plot software and its integration with database.

n. Online user guide and help functions.

o. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.

p. System speed of response compared to requirements indicated.

q. For Each Network and Programmable Application Controller:

1) Memory: Programmed data, parameters, trend and alarm history collected during normal operation is not lost during power failure.
2) Operator Interface: Ability to connect directly to each type of digital controller with a portable workstation and mobile device. Show that maintenance personnel interface tools perform as indicated in manufacturer's technical literature.
3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.
4) Electric Power: Ability to disconnect any controller safely from its power source.
5) Wiring Labels: Match control drawings.
6) Network Communication: Ability to locate a controller's location on network and communication architecture matches Shop Drawings.
7) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators and devices.

r. For Each Operator Workstation:

1) I/O points lists agree with naming conventions.
2) Graphics are complete.
3) UPS unit, if applicable, operates.

s. Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management. Use ASHRAE 135 protocol analyzer to help identify devices, view network traffic, and verify interoperability. Requirements must be met even if only one manufacturer's equipment is installed.

1) Data Presentation: On each operator workstation, demonstrate graphic display capabilities.
2) Reading of Any Property: Demonstrate ability to read and display any used readable object property of any device on network.

3) Set Point and Parameter Modifications: Show ability to modify set points and tuning parameters indicated. Modifications are made with messages and write services initiated by an operator using workstation graphics, or by completing a field in a menu with instructional text.
4) Peer-to-Peer Data Exchange: Network devices are installed and configured to perform without need for operator intervention to implement Project sequence of operation and to share global data.
5) Alarm and Event Management: Alarms and events are installed and prioritized according to Owner. Demonstrate that time delays and other logic are set up to avoid nuisance tripping. Show that operators with sufficient privileges are permitted.
6) Schedule Lists: Schedules are configured for start and stop, mode change, occupant overrides, and night setback as defined in sequence of operations.
7) Schedule Display and Modification: Ability to display any schedule with start and stop times for calendar year. Show that all calendar entries and schedules are modifiable from any connected operator workstation by an operator with sufficient privilege.
8) Archival Storage of Data: Data archiving is handled by operator workstation and server and local trend archiving and display is accomplished.
9) Modification of Trend Log Object Parameters: Operator with sufficient privilege can change logged data points, sampling rate, and trend duration.
10) Device and Network Management:

    a) Display of network device status.
    b) Display of BACnet Object Information.
    c) Silencing devices transmitting erroneous data.
    d) Time synchronization.
    e) Remote device re-initialization.
    f) Backup and restore network device programming and master database(s).
    g) Configuration management of routers.

3.23 EXTENDED OPERATION TEST

A. Extended operation test is intended to simulate normal operation of DDC system by Owner.

B. Operate DDC system for an operating period of 14 consecutive calendar days following Substantial Completion. Coordinate exact start date of testing with Owner.

C. Provide an operator familiar with DDC system installed to man an operator workstation while on-site during eight hours of each normal business day occurring during operating period.

D. During operating period, DDC system shall demonstrate correct operation and accuracy of monitored and controlled points as well as operation capabilities of sequences, logs, trends, reports, specialized control algorithms, diagnostics, and other software indicated.

1. Correct defects of hardware and software when it occurs.

E. Definition of Failures and Downtime during Operating Period:

1. Failed I/O point constituting downtime is an I/O point failing to perform its intended function consistently and a point physically failed due to hardware and software.
2. Downtime is when any I/O point in DDC system is unable to fulfill its' required function.

3. Downtime shall be calculated as elapsed time between a detected point failure as confirmed by an operator and time point is restored to service.
4. Maximum time interval allowed between DDC system detection of failure occurrence and operator confirmation shall be 0.5 hours.
5. Downtime shall be logged in hours to nearest 0.1 hour.
6. Power outages shall not count as downtime, but shall suspend test hours unless systems are provided with UPS and served through a backup power source.
7. Hardware or software failures caused by power outages shall count as downtime.

F. During operating period, log downtime and operational problems are encountered.

1. Identify source of problem.
2. Provide written description of corrective action taken.
3. Record duration of downtime.
4. Maintain log showing the following:

    a. Time of occurrence.
    b. Description of each occurrence and pertinent written comments for reviewer to understand scope and extent of occurrence.
    c. Downtime for each failed I/O point.
    d. Running total of downtime and total time of I/O point after each problem has been restored.

5. Log shall be available to Owner for review at any time.

G. For DDC system to pass extended operation test, total downtime shall not exceed 2 percent of total point-hours during operating period.

1. Failure to comply with minimum requirements of passing at end of operating period indicated shall require that operating period be extended one consecutive day at a time until DDC system passes requirement.

H. Evaluation of DDC system passing test shall be based on the following calculation:

1. Downtime shall be counted on a point-hour basis where total number of DDC system point-hours is equal to total number of I/O points in DDC system multiplied by total number of hours during operating period.
2. One point-hour of downtime is one I/O point down for one hour. Three points down for five hours is a total of 15 point-hours of downtime. Four points down for one-half hour is 2 point-hours of downtime.
3. Example Calculation: Maximum allowable downtime for 30-day test when DDC system has 1000 total I/O points (combined analog and binary) and has passing score of 1 percent downtime is computed by 30 days x 24 h/day x 1000 points x 1 percent equals 7200 point-hours of maximum allowable downtime.

I. Prepare test and inspection reports.

3.24 ADJUSTING

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

3.25 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

B. Extent of Training:

1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
3. Minimum Training Requirements:

    a. Provide not less than five days of training total.
    b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.
    c. Total days of training shall be broken into not more than three separate training classes.
    d. Each training class shall be not less than two consecutive day(s).

C. Training Schedule:

1. Schedule training with Owner 20 business days before expected Substantial Completion.
2. Schedule training to provide Owner with at least 15 business days of notice in advance of training.
3. Training shall occur within normal business hours at a mutually agreed on time. Unless otherwise agreed to, training shall occur Monday through Friday, except on U.S. Federal holidays, with two morning sessions and two afternoon sessions. Each morning session and afternoon session shall be split in half with 30-minute break between sessions. Morning and afternoon sessions shall be separated by 60 -minute lunch period. Training, including breaks and excluding lunch period, shall not exceed eight hours per day.
4. Provide staggered training schedule as requested by Owner.

D. Training Attendee List and Sign-in Sheet:

1. Request from Owner in advance of training a proposed attendee list with name, phone number and e-mail address.
2. Provide a preprinted sign-in sheet for each training session with proposed attendees listed and no fewer than six blank spaces to add additional attendees.
3. Preprinted sign-in sheet shall include training session number, date and time, instructor name, phone number and e-mail address, and brief description of content to be covered during session. List attendees with columns for name, phone number, e-mail address and a column for attendee signature or initials.
4. Circulate sign-in sheet at beginning of each session and solicit attendees to sign or initial in applicable location.
5. At end of each training day, send Owner an e-mail with an attachment of scanned copy (PDF) of circulated sign-in sheet for each session.

E. Training Attendee Headcount:

1. Plan in advance of training for five attendees.
2. Make allowance for Owner to add up to one attendee(s) at time of training.
3. Headcount may vary depending on training content covered in session. Attendee access may be restricted to some training content for purposes of maintaining system security.

F. Training Attendee Prior Knowledge: For guidance in planning required training and instruction, assume attendees have the following:
   1. Basic knowledge of HVAC systems.
   2. Basic knowledge of DDC system and products installed.

G. Attendee Training Manuals:

   1. Provide each attendee with a color hard copy of all training materials and visual presentations.
   2. Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
   3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.

H. Instructor Requirements:

   1. One or multiple qualified instructors, as required, to provide training.
   2. Instructors shall have not less than five years of providing instructional training on not less than five past projects with similar DDC system scope and complexity to DDC system installed.

I. Organization of Training Sessions:

   1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:

      a. Daily operators.
      b. Advanced operators.
      c. System managers and administrators.

   2. Plan and organize training sessions to group training content to protect DDC system security. Some attendees may be restricted to some training sessions that cover restricted content for purposes of maintaining DDC system security.

J. Training Outline:

   1. Submit training outline for Owner review at least 10 business day before scheduling training.
   2. Outline shall include a detailed agenda for each training day that is broken down into each of four training sessions that day, training objectives for each training session and synopses for each lesson planned.

K. On-Site Training:

   1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power and data connectivity for instructor and each attendee.
   2. Instructor shall provide training materials, projector and other audiovisual equipment used in training.
   3. Provide as much of training located on-site as deemed feasible and practical by Owner.
   4. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration and service requirements.
   5. Operator workstation provided with DDC system shall be used in training. If operator workstation is not indicated, provide a temporary workstation to convey training content.

L. Off-Site Training:

1. Provide conditioned training rooms and workspace with ample tables desks or tables, chairs, power and data connectivity for each attendee.
2. Provide capability to remotely access to Project DDC system for use in training.
3. Provide a workstation for use by each attendee.

M. Training Content for Daily Operators:

1. Basic operation of system.
2. Understanding DDC system architecture and configuration.
3. Understanding each unique product type installed including performance and service requirements for each.
4. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm and each unique optimization routine.
5. Operating operator workstations, printers and other peripherals.
6. Logging on and off system.
7. Accessing graphics, reports and alarms.
8. Adjusting and changing set points and time schedules.
9. Recognizing DDC system malfunctions.
10. Understanding content of operation and maintenance manuals including control drawings.
11. Understanding physical location and placement of DDC controllers and I/O hardware.
12. Accessing data from DDC controllers.
13. Operating portable operator workstations.
14. Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.
15. Running each specified report and log.
16. Displaying and demonstrating each data entry to show Project-specific customizing capability. Demonstrating parameter changes.
17. Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.
18. Executing digital and analog commands in graphic mode.
19. Demonstrating control loop precision and stability via trend logs of I/O for not less than 10 percent of I/O installed.
20. Demonstrating DDC system performance through trend logs and command tracing.
21. Demonstrating scan, update, and alarm responsiveness.
22. Demonstrating spreadsheet and curve plot software, and its integration with database.
23. Demonstrating on-line user guide, and help function and mail facility.
24. Demonstrating multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
25. Demonstrating the following for HVAC systems and equipment controlled by DDC system:

    a. Operation of HVAC equipment in normal-off, -on and failed conditions while observing individual equipment, dampers and valves for correct position under each condition.
    b. For HVAC equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers or gateways, as applicable.
    c. Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles and other modes of operation indicated.
    d. Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.

e. Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.
f. Each control loop responds to set point adjustment and stabilizes within time period indicated.
g. Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.

N. Training Content for Advanced Operators:

1. Making and changing workstation graphics.
2. Creating, deleting and modifying alarms including annunciation and routing.
3. Creating, deleting and modifying point trend logs including graphing and printing on an ad-hoc basis and operator-defined time intervals.
4. Creating, deleting and modifying reports.
5. Creating, deleting and modifying points.
6. Creating, deleting and modifying programming including ability to edit control programs off-line.
7. Creating, deleting and modifying system graphics and other types of displays.
8. Adding DDC controllers and other network communication devices such as gateways and routers.
9. Adding operator workstations.
10. Performing DDC system checkout and diagnostic procedures.
11. Performing DDC controllers operation and maintenance procedures.
12. Performing operator workstation operation and maintenance procedures.
13. Configuring DDC system hardware including controllers, workstations, communication devices and I/O points.
14. Maintaining, calibrating, troubleshooting, diagnosing and repairing hardware.
15. Adjusting, calibrating and replacing DDC system components.

O. Training Content for System Managers and Administrators:

1. DDC system software maintenance and backups.
2. Uploading, downloading and off-line archiving of all DDC system software and databases.
3. Interface with Project-specific, third-party operator software.
4. Understanding password and security procedures.
5. Adding new operators and making modifications to existing operators.
6. Operator password assignments and modification.
7. Operator authority assignment and modification.
8. Workstation data segregation and modification.

P. Video of Training Sessions:

1. Provide a digital video and audio recording of each training session. Create a separate recording file for each session.
2. Stamp each recording file with training session number, session name and date.
3. Provide Owner with **two** copies of digital files on DVDs or flash drives for later reference and for use in future training.
4. Owner retains right to make additional copies for intended training purposes without having to pay royalties.

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SECTION 23 23 00

REFRIGERANT 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. Refrigerant pipes and fittings.
2. Refrigerants.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of refrigerant piping, and piping specialty.

B. Shop Drawings:

1. Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes; flow capacities; valve arrangements and locations; slopes of horizontal runs; oil traps; double risers; wall and floor penetrations; and equipment connection details.
2. Show interface and spatial relationships between piping and equipment.
3. Shop Drawing Scale: 1/4 inch equals 1 foot.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to 2010 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.7 PRODUCT STORAGE AND HANDLING

A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

1.8 MEASUREMENT AND PAYMENT

A. Measurement: Metal Ducts shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Metal Ducts shall include full compensation for furnishing all labor, materials, tools, equipment, supports, and incidentals, and for doing all Work involved in constructing metal ducts complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:
   1. Suction Lines for Heat-Pump Applications: 535 psig.
   2. Hot-Gas and Liquid Lines: 535 psig.

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 88, Type K .

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

2.3 REFRIGERANTS

A. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications:
   1. NPS 3/4 to NPS 1 and Smaller: Copper, Type K, annealed- or drawn-temper tubing and wrought-copper fittings with soldered joints.

3.2 PIPING INSTALLATION

A. 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 Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. 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.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:

   1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.

2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Liquid lines may be installed level.

P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:

1. Shot blast the interior of piping.
2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

S. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.3 PIPE 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. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

3.4 HANGERS AND SUPPORTS

A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.

2. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod diameters:

1. NPS 1/2: Maximum span, 60 inches; minimum rod, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod, 1/4 inch.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.

    a. Fill system with nitrogen to the required test pressure.
    b. System shall maintain test pressure at the manifold gage throughout duration of test.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

B. Prepare test and inspection reports.

3.6 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.7 ADJUSTING

A. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

B. Adjust set-point temperature of air-conditioning controllers to the system design temperature.

C. Perform adjustments before operating the refrigeration system, according to manufacturer's written instructions.

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SECTION 23 31 13

METAL DUCTS

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. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.
6. Seismic-restraint devices.

B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:
1. Sealants and gaskets.
2. Seismic-restraint devices.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

C. Delegated-Design Submittal:
   1. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

   1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
   2. Suspended ceiling components.
   3. Structural members to which duct will be attached.
   4. Size and location of initial access modules for acoustical tile.
   5. Penetrations of smoke barriers and fire-rated construction.
   6. Items penetrating finished ceiling including the following:

      a. Luminaires.
      b. Air outlets and inlets.
      c. Speakers.
      d. Access panels.
      e. Perimeter moldings.

B. Welding certificates.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports

1.7 MEASUREMENT AND PAYMENT

A. Measurement: Metal Ducts shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Metal Ducts shall include full compensation for furnishing all labor, materials, tools, equipment, supports, and incidentals, and for doing all Work involved in constructing metal ducts complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - **PRODUCTS**

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.4 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 6 inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F .

9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.5 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

F. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

G. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2.6 SEISMIC-RESTRAINT DEVICES

A. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

B. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

C. Restraint Cables: ASTM A 492, stainless-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

D. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts at a minimum to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Unconditioned Space, Exhaust Ducts: Seal Class C.
3. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
4. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
5. Conditioned Space, Exhaust Ducts: Seal Class B.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." and ASCE/SEI 7.

1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
2. Brace a change of direction longer than 12 feet .

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

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

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install stainless-steel anchors for interior applications and exposed to weather.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:
   a. Supply Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.
   b. Exhaust Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections100 percent of total installed duct area for each designated pressure class.
   c. Outdoor Air Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.

5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

C. Duct system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.9 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.

4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.10 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

B. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

    a. Velocity 1000 fpm or Lower:

        1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
        2) Mitered Type RE 4 without vanes.

    b. Velocity 1000 to 1500 fpm:

        1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
        2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
        3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

    c. Velocity 1500 fpm or Higher:

        1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
        2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
        3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

    a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
    b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
    c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

C. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.
b. Rectangular Main to Round Branch: Spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

a. Velocity 1000 fpm or Lower: 90-degree tap.
b. Velocity 1000 to 1500 fpm: Conical tap.
c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 23 31 13

SECTION 23 33 00

AIR DUCT ACCESSORIES

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. Backdraft dampers.
2. Manual volume dampers.
3. Fire dampers.
4. Flange connectors.
5. Turning vanes.
6. Flexible connectors.
7. Duct accessory hardware.

B. Related Requirements:

1. Section 233346 "Flexible Ducts" for insulated and non-insulated flexible ducts.
2. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

    a. Special fittings.
    b. Manual volume damper installations.
    c. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 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. Fusible Links: Furnish quantity equal to 100 percent of amount installed.

1.7 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Exposed-Surface Finish: Mill phosphatized.

B. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

C. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT DAMPERS

A. Description: Gravity balanced.

B. Maximum Air Velocity: 1000 fpm.

C. Maximum System Pressure: 1-inch wg.

D. Frame: Hat-shaped, 0.094-inch- (thick, galvanized sheet steel, with welded corners or mechanically attached and mounting flange.

E. Blades: Multiple single-piece blades, center pivoted, maximum 6-inch width, 0.050-inch- thick aluminum sheet with sealed edges.

F. Blade Action: Parallel.

G. Blade Seals: Neoprene, mechanically locked.

H. Blade Axles:

1. Material: Galvanized steel.
2. Diameter: 0.20 inch.

I. Tie Bars and Brackets: Galvanized steel.

J. Return Spring: Adjustable tension.

K. Bearings: Steel ball or synthetic pivot bushings.

L. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Chain pulls.

5. Screen Mounting: Rear mounted.
6. Screen Material: Galvanized steel.
7. Screen Type: Insect.
8. 90-degree stops.

2.4 MANUAL VOLUME DAMPERS

A. Low-Leakage, Steel, Manual Volume Dampers:
1. Comply with AMCA 500-D testing for damper rating.
2. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
3. Suitable for horizontal or vertical applications.

4. Frames:

    a. Hat shaped.
    b. 0.094-inch- thick, galvanized sheet steel.
    c. Mitered and welded corners.
    d. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Galvanized, roll-formed steel, 0.064 inchthick.

6. Blade Axles: Galvanized steel.
7. Bearings:

    a. Stainless-steel sleeve.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Blade Seals: Neoprene.
9. Jamb Seals: Cambered stainless steel.
10. Tie Bars and Brackets: Galvanized steel.
11. Accessories:

    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

B. Jackshaft:

1. Size: 1-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.5 FIRE DAMPERS

A. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.

B. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.

C. Fire Rating: 1-1/2 and 3 hours.

D. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.138 inch or 0.39 inch thick, as indicated, and of length to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

F. Mounting Orientation: Vertical or horizontal as indicated.

G. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.

H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

I. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

2.6 FLANGE CONNECTORS

A. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

B. Material: Galvanized steel.

C. Gage and Shape: Match connecting ductwork.

2.7 TURNING VANES

A. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

B. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

D. Vane Construction: Double wall.

E. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.8 DUCT-MOUNTED ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

   a. Double wall, rectangular.
   b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
   c. Vision panel.
   d. Hinges and Latches: 1-by-1-inchbutt or piano hinge and cam latches.
   e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:

   a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches Square: Continuous and two sash locks.
   c. Access Doors up to 24 by 48 Inches : Continuous and two compression latches with outside and inside handles.
   d. Access Doors Larger Than 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.

2.9 FLEXIBLE CONNECTORS

A. Materials: Flame-retardant or noncombustible fabrics.

B. Coatings and Adhesives: Comply with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.

D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd..
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

F. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.

1. Minimum Weight: 16 oz./sq. yd..
2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.

3. Service Temperature: Minus 67 to plus 500 deg F .

G. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.10 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Compliance with ASHRAE/IESNA 90.1-2004 includes Section 6.4.3.3.3 - "Shutoff Damper Controls," restricts the use of backdraft dampers, and requires control dampers for certain applications. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire dampers according to UL listing.

H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream and downstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-foot spacing.
8. Upstream from turning vanes.
9. Control devices requiring inspection.
10. Elsewhere as indicated.

I. Install access doors with swing against duct static pressure.

J. Access Door Sizes:
1. Two-Hand Access: 12 by 6 inches.
2. Head and Hand Access: 18 by 10 inches.
3. Head and Shoulders Access: 21 by 14 inches.
4. Body Access: 25 by 14 inches.
5. Body plus Ladder Access: 25 by 17 inches.

K. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment.

M. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

N. Install duct test holes where required for testing and balancing purposes.

O. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.

5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 23 33 00

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SECTION 23 34 23

HVAC POWER VENTILATORS

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. Centrifugal wall ventilators.
2. Ceiling-mounted ventilators.
3. In-line centrifugal fans.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations.

B. Operating Limits: Classify according to AMCA 99.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Roof curbs.
7. Fan speed controllers.

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. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For unit hangars and supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Roof framing and support members relative to duct penetrations.
2. Ceiling suspension assembly members.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.7 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. Belts: One set for each belt-driven unit.

1.8 QUALITY ASSURANCE

A. 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.

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

1.9 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.10 MEASUREMENT AND PAYMENT

A. Measurement: HVAC Power Ventilators shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for HVAC Power Ventilators shall include full compensation for furnishing all labor, materials, tools, equipment, supports, and incidentals, and for doing all Work involved in constructing HVAC power ventilators complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL WALL VENTILATORS

A. Housing: Removable, heavy-gage, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

B. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

C. Belt Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
5. Fan and motor isolated from exhaust airstream.

D. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
4. Wall Grille: Ring type for flush mounting.

2.2 CEILING-MOUNTED VENTILATORS

A. Housing: Steel, lined with acoustical insulation.

B. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

C. Grille: Stainless steel, louvered grille with flange on intake and thumbscrew attachment to fan housing.

D. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

E. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
3. Isolation: Rubber-in-shear vibration isolators.

2.3 IN-LINE CENTRIFUGAL FANS

A. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

B. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.

C. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

D. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

E. Accessories:
1. Companion Flanges: For inlet and outlet duct connections.
2. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.5 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Equipment Mounting:

1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

C. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Section 077200 "Roof Accessories" for installation of roof curbs.

D. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

E. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1 inch . Vibration-control devices are specified in Section 230548 "Vibration and Seismic Controls for HVAC."

F. Install units with clearances for service and maintenance.

G. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. 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.

B. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION 23 34 23

SECTION 23 37 13.23

REGISTERS AND GRILLES

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. Fixed face grilles.

B. Related Requirements:

   1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to registers and grilles.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

   1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
   2. Register and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

   1. Ceiling suspension assembly members.
   2. Method of attaching hangers to building structure.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
   5. Duct access panels.

B. Source quality-control reports.

1.5 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 GRILLES

A. Fixed Face Grille:
1. Material: Steel.
2. Finish: Baked enamel, white.
3. Face Blade Arrangement: Horizontal; spaced 1/2 inch apart.
4. Face Arrangement: Perforated core.
5. Core Construction: Integral.
6. Frame: 1-1/4 inches wide.
7. Mounting: Lay in.

2.2 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate registers and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where registers and grilles are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install registers and grilles level and plumb.

B. Outlets and Inlets Locations: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install registers and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust registers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 37 13.23

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SECTION 23 81 26

SPLIT-SYSTEM AIR-CONDITIONERS

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 split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Shop Drawings: Include plans, refrigerant piping layout, 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. Wiring Diagrams: For power, signal, and control wiring.
3. Piping Diagrams: For refrigerant piping, fittings, and accessories.
4. Thermostat (Multi-Function Controller) and BACnet® gateway.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.6 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. Filters: One set(s) for each air-conditioning unit.
2. Gaskets: One set(s) for each access door.

1.7 QUALITY ASSURANCE

A. 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.

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

   a. For Compressor: Five year(s) from date of Substantial Completion.
   b. For Parts: Five year(s) from date of Substantial Completion.
   c. For Labor: Five year(s) from date of Substantial Completion.

1.10 MEASUREMENT AND PAYMENT

A. Measurement: Split-System Air-Conditioners shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Split-System Air-Conditioners shall include full compensation for furnishing all labor, materials, tools, equipment, supports, and incidentals, and for doing all Work involved in constructing split-system air-conditioners complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Samsung Electronics DVM S (Variable Refrigerant Flow)

B. Or approved equal.

2.2 INDOOR UNITS (5 TONS OR LESS)

A. Ceiling-Suspended, Evaporator-Fan Components:

1. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, and an auto restart function.
2. The indoor unit shall have a discharge air temperature sensor.
3. The indoor unit discharge temperature sensor shall allow configuration to control unit operation based on target cooling and heating discharge air temperatures (cooling: 46~64º F, heating: 86~109º F).
4. The indoor unit discharge temperature sensor reading shall be visible on central control and manufacturer provided service software.
5. The indoor unit discharge temperature setting shall be controllable via central control wired controllers. The BACnet gateway shall also allow discharge air temperature control via BACnet protocol.
6. The indoor unit shall have an integral condensate pump as standard with 29” maximum lift.
7. Cabinet: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
8. Insulation: Faced, glass-fiber duct liner.
9. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
10. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
    a. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
    b. The indoor fan shall consist of three (3) speeds, Low, Mid, and High.
11. Fan Motors:

a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
c. Wiring Terminations: Connect motor to chassis wiring with plug connection.

12. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
13. Filters: Permanent, cleanable.

14. Electrical:
a. The unit electrical power shall be 208/230 volts, 1-phase, and 60 hertz.
b. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).
c. The control circuit between the indoor units, MCU (Mode Control Unit) and the heat pump outdoor unit shall be 0.5VDC - 7VDC completed using stranded, annealed copper conductor, two-core, 16 AWG, shielded cable to provide total integration of the system.
d. The indoor unit shall have a thermal fuse under high-voltage terminal block to disable unit in the event of overheating due to electrical malfunction/poor connection.

15. Controls:
a. The indoor unit shall have a removable EEPROM on its PCB to store all unit data. All data on the indoor unit EEPROM shall be viewable from the manufacturer provided service software. The indoor unit main EEPROM shall be removable allowing replacement of indoor unit PCB without losing digital, field programmed data. The indoor unit removable EEPROM shall store the following unit data: unit model number, unit serial number, unit PCB firmware and MICOM version, and field programmed unit name/tag viewable on controls and service software.
b. The indoor unit shall have advanced unoccupied room control capability. Unoccupied room control can be used to reduce system demand when a room is not occupied by changing zone settings. Unoccupied room control shall be done with MIM-B14 external contact control module (refer to Part 4 of this guide specification). The unoccupied settings can be modified with MIM-D00AN, MIM-D01AUN, MIM-B17N, MIM-B17BUN, MIM-B18N, or MIM-B18BUN gateways or programmed with the manufacturer provided service software. Unoccupied room control shall provide four setting options to modify indoor unit operation when in “unoccupied mode”. Settings shall include indoor unit ON/OFF, fan speed, and set temperature adjustment.
c. The indoor unit shall feature a Dual Set point function that allows users to set separate heating and cooling set temperatures using MWR-WG00JN wired controller and central control options MIM-D01AUN, MIM-B17BUN, and MIM-B18BUN. Dual set temperature allows the user to specify a deadband where the unit will not heat or cool when room temperature is between the heating and cooling set temperatures. Dual set temperature can be used with heat pump or heat recovery systems.
d. The indoor unit shall feature an Emergency Temperature Output (ETO) function that will provide a signal when an indoor unit is in error status. When enabling ETO, a high room temperature threshold can also be programmed to provide a signal when the room temperature limit has been exceeded. The ETO signal can be used to activate backup systems, provide a simple signal to a building management system, or to provide a simple visual/audible notification locally (ex: LED, buzzer, etc.). An MIM-B14 External Contact Control interface module is required for each unit that will provide or receive an ETO signal.

B. 4-Way Ceiling Cassette, Evaporator-Fan Components:

1. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function. Indoor unit and refrigerant pipes shall be charged with dehydrated air (Nitrogen gas) before shipment from the factory.

2. The indoor unit shall include a Wind-Free™ function that will close the supply air outlet louvers while in cooling mode to gently disperse cool air into the space through thousands of micro-holes on the fascia panel without blowing directly onto occupants. Wind-Free™ operation prevents direct airflow onto occupants thus increasing occupant comfort.

3. The Wind-Free™ 4-way cassette can be configured for 2-stage operation, cooling the space with the louver open (fixed or swing) until the room temperature nears set temperature. Once room temperature is near set temperature, Wind-Free™ operation will start automatically, closing the louver and using the face of the fascia panel to gently cool the space with still air* through thousands of micro-holes.

4. The indoor unit Wind-Free™ fascia panel shall include a humidity sensor to prevent condensation formation by restricting Wind-Free™ operation in high humidity conditions.

5. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect.
   a. Service of electronics, high and low voltage connection, condensate pump, fan, fan motor, sensors, EEV, condensate pan, and other components shall be accessible from the bottom of the cassette unit not requiring access from the sides of the unit.
   b. Each corner portion of the panel cabinet is detachable, which gives easy access to adjust the height.
   c. The cabinet shall have provisions for a field installed, filtered, outside air intake. A booster fan is necessary. A 12V DC relay terminal is available to control a booster fan (with separate PCB connector).
   d. The cabinet shall have a fresh air intake opening to accommodate the introduction of fresh air into the space.
   e. The cabinet shall be provided with outdoor air intake fitting to accommodate higher CFM.
   f. The indoor unit fascia panel shall have LED indicator lights on the front and an IR receiver for wireless controller use.

6. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
7. Fan:
   a. The indoor fan assembly shall be a turbo fan direct driven by a single motor.
   b. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
   c. The indoor fan shall consist of three (3) speeds, Low, Mid, and High.
   d. The auto swing air outlet vanes (4) shall be capable of automatically swinging up and down for uniform air distribution.
   e. The supply air vanes shall have independent control capability (32° – 65° control range) adjustable with optional wireless or wired controllers.
8. Fan Motors:

   a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
   b. Multitapped, multispeed with internal thermal protection and permanent lubrication.

9. Filters: Permanent, cleanable

10. Electrical:
    a. The unit electrical power shall be 208/230 volts, 1-phase, and 60 hertz.
    b. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).
    c. The control circuit between the indoor units, MCU (Mode Control Unit) and the heat pump/heat recovery outdoor unit shall be 0.5VDC - 7VDC completed using stranded, annealed copper conductor, two-core, 16 AWG, shielded cable to provide total integration of the system.
    d. The indoor unit shall have a thermal fuse under high-voltage terminal block to disable unit in the event of overheating due to electrical malfunction/poor connection.

11. Controls:
    a. The indoor unit shall have a removable EEPROM on its PCB to store all unit data. All data on the indoor unit EEPROM shall be viewable from the manufacturer provided service software. The indoor unit main EEPROM shall be removable allowing replacement of indoor unit PCB without losing digital, field programmed data. The indoor unit removable EEPROM shall store the following unit data: unit model number, unit serial number, unit PCB firmware and MICOM version, and field programmed unit name/tag viewable on controls and service software.
    b. The indoor unit shall have advanced unoccupied room control capability. Unoccupied room control can be used to reduce system demand when a room is not occupied by changing zone settings. Unoccupied room control shall be done with MIM-B14 external contact control module (refer to Part 4 of this guide specification). The unoccupied settings can be modified with MIM-D00AN, MIM-D01AUN, MIM-B17N, MIM-B17BUN, MIM-B18N, or MIM-B18BUN gateways or programmed with the manufacturer provided service software. Unoccupied room control shall provide four setting options to modify indoor unit operation when in "unoccupied mode". Settings shall include indoor unit ON/OFF, fan speed, and set temperature adjustment.
    c. The indoor unit shall feature a Dual Set point function that allows users to set separate heating and cooling set temperatures using MWR-WG00JN wired controller and central control options MIM-D01AUN, MIM-B17BUN, and MIM-B18BUN. Dual set temperature allows the user to specify a deadband where the unit will not heat or cool when room temperature is between the heating and cooling set temperatures. Dual set temperature can be used with heat pump or heat recovery systems.
    d. The indoor unit shall feature an Emergency Temperature Output (ETO) function that will provide a signal when an indoor unit is in error status. When enabling ETO, a high room temperature threshold can also be programmed to provide a signal when the room temperature limit has been exceeded. The ETO signal can be used to activate backup systems, provide a simple signal to a building management system, or to provide a simple visual/audible notification locally (ex: LED, buzzer, etc.). An MIM-B14 External Contact Control interface module is required for each unit that will provide or receive an ETO signal.

2.3 OUTDOOR UNITS (5 TONS OR LESS)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

    a. Compressor Type: Asymmetric, hermetically sealed, inverter driven, flash injected DC Scroll type. No fixed capacity compressors shall be present in the refrigerant system.
    b. Refrigerant: R-410A .
    c. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110. The coil shall be protected with an integral metal guard.

3. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.
    a. All fan motors shall be variable speed BLDC type.
    b. All fan motors shall have inherent protection, thermal protection, and have permanently lubricated bearings, and be completely variable speed.
    c. All fan motors shall be mounted for quiet operation.
    d. All fans shall be provided with a raised guard to prevent contact with moving parts.
    e. The outdoor unit shall have vertical discharge airflow.
6. Mounting Base: Polyethylene.
7. The sum of connected capacity of all indoor air handlers shall range from 50% to 130% of outdoor rated capacity.
8. The Heat Pump condensing unit salt spray test method: ASTM B117-18 - the heat exchanger showed no unusual rust or corrosion development to 2,280 hours.
9. The heat pump system shall have the ability to change operation mode without turning off the compressors allowing for constant heating and cooling operation.
10. The outdoor unit shall have advanced oil recovery cycle logic operation that shall not interrupt heating or cooling operation. The oil recovery cycle duration shall not exceed three (3) minutes while in cooling mode or six (6) minutes while in heating mode. While in heat mode, any defrost cycle lasting over three (3) minutes shall be considered an oil recovery cycle.
11. Advanced intelligent defrost logic to significantly reduce defrost cycle frequency by monitoring air resistance across the condenser coil during heating operation to determine defrost operation initiation to prevent unnecessary defrost cycles.
12. Outdoor unit (individual modules) shall have a sound rating no higher than 64 dB (A).
13. Both refrigerant lines from the outdoor unit shall be insulated.
14. The heat pump outdoor unit shall have an accumulator with accumulator return valve control.
15. The heat pump outdoor unit shall have a high pressure safety switch, high voltage fuses, over-current protection, phase detection protection, thermal fan protection, low pressure protection, compressor overcurrent protection, fan motor voltage protection, current transformer(s), crank case heating, and intelligent logic to ensure proper operation within unit design limitations and operational parameters.
16. The Inverter compressor driver PCB(s) shall cooled with liquid refrigerant circuit(s) to operate at optimal temperatures and to prevent failure due to overheating. No compressor inverter PCB's will be cooled by air over heat sink. Cooling inverter components without air-cooling fins prevents failure due to environmental contaminants.
17. The heat pump outdoor unit shall be capable of operating in cooling mode between 23°F ~ 120°F outside ambient temperatures.
18. The heat pump outdoor unit shall be capable of operating in cooling mode below 23°F down to 5°F outside ambient temperature with the addition of LACH side and rear guards.
19. The heat pump outdoor unit shall be capable of operating in cool mode down to -13°F ambient temperatures with use of low ambient cooling hood (LACH-1, LACH-2) and side/rear guards.

20. The heat pump outdoor unit shall be capable of operating in heating mode between -13°F ~ 75°F ambient temperatures.
21. The heat pump system shall allow adjustment of target evaporator coil temperatures in cooling mode and target heating discharge pressures depending on project conditions for heating and cooling calibration thus saving energy.
22. The heat pump outdoor unit shall have a high efficiency, individual oil separators for each compressor plus additional logic controls to ensure adequate oil volume in the compressor is maintained.
23. The heat pump outdoor unit shall have a flat-plate type subcooler to sub cool liquid refrigerant further to increase capacity and performance with long pipe lengths and to decrease refrigerant sounds at indoor equipment.
24. The compressors shall have flash injection capability to increase performance in heating mode. This will be automatically enabled by the outdoor unit(s) by forcing saturated refrigerant as a liquid flash mix directly into the scroll compression cycle increasing mass flow and overall system capacity. Compressors without flash injection shall not be present in the VRF heat pump system.
25. The heat pump outdoor unit shall have a removable EEPROM at the main PCB to store all unit data. All data on the outdoor unit EEPROM shall be viewable from the manufacturer provided service software. The outdoor unit main EEPROM shall be removable allowing replacement of outdoor unit PCB without losing digital, field programmed data. The outdoor unit removable EEPROM shall store the following unit data: unit model number, unit serial number, unit main PCB firmware and MICOM version, sub-PCB firmware and MICOM version, fan PCB firmware and MICOM version, inverter PCB 1 and inverter PCB 2 firmware and MICOM version, auto-trial commissioning startup data, the last 30 minutes of operation data, and field programmed unit name/tag viewable on controls and service software.
26. The heat pump outdoor unit shall have the ability to discharge inverter PCB capacitor voltage using service buttons on the outdoor unit main PCB. The capacitor stored-voltage discharge feature shall allow safe inverter PCB replacement.
27. The heat pump outdoor unit shall have outdoor unit pump-down operation capability allowing storage of refrigerant while opening sealed refrigerant pipe system outside of outdoor unit chassis while performing service. The outdoor unit refrigerant storage shall be greater than the supplied factory R-410A charge.
28. The heat pump outdoor unit shall have individual outdoor module pump-out operation capability allowing the majority of refrigerant in an outdoor unit to be pumped out. The pump-out feature shall allow service of sealed refrigerant system within an outdoor unit chassis.
29. The heat pump outdoor unit shall allow temporary disabling of individual compressors to allow system operation at reduced capacity after a compressor or compressor component related issue (when more than one compressor is present in system). Disabling of a compressor shall temporarily remove error codes and allow system operation.
30. The heat pump outdoor unit compressors shall have a soft-start function to reduce electricity demand during system start and to increase compressor reliability.
31. In the event of system error due to outdoor unit failure, the heat pump outdoor unit shall display codes that specify a precise error and which outdoor unit PCB is the cause.
32. The heat pump system shall support system auto-addressing allowing system commissioning without manually configuring indoor unit addresses.
33. Electrical:
    a. The outdoor unit electrical power shall be 208/230 volts, 3 phase, 60 hertz.
    b. The 208/230 VAC unit shall be capable of satisfactory operation within voltage limitations of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).
    c. The outdoor unit shall be controlled by integral microprocessors.
    d. The control circuit between the indoor units and the outdoor unit shall be 0.5VDC - 7VDC completed using stranded, annealed copper conductor, 16 AWG, shielded, two-core cable to provide total integration of the system.

2.4 OUTDOOR UNITS (6 TONS OR MORE)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

    a. Compressor Type: Asymmetric, hermetically sealed, inverter driven, flash injected DC Scroll type. No fixed capacity compressors shall be present in the refrigerant system.
    b. Refrigerant: R-410A.
    c. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110. The coil shall be protected with an integral metal guard.

3. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.
6. Mounting Base: Polyethylene.
7. The sum of connected capacity of all indoor air handlers shall range from 50% to 130% of outdoor rated capacity.
8. The Heat Pump condensing unit salt spray test method: ASTM B117-18 - the heat exchanger showed no unusual rust or corrosion development to 2,280 hours.
9. The heat pump system shall have the ability to change operation mode without turning off the compressors allowing for constant heating and cooling operation.
10. The outdoor unit shall have advanced oil recovery cycle logic operation that shall not interrupt heating or cooling operation. The oil recovery cycle duration shall not exceed three (3) minutes while in cooling mode or six (6) minutes while in heating mode. While in heat mode, any defrost cycle lasting over three (3) minutes shall be considered an oil recovery cycle.
11. Advanced intelligent defrost logic to significantly reduce defrost cycle frequency by monitoring air resistance across the condenser coil during heating operation to determine defrost operation initiation to prevent unnecessary defrost cycles.
12. Outdoor unit (individual modules) shall have a sound rating no higher than 64 dB (A).
13. Both refrigerant lines from the outdoor unit shall be insulated.
14. The heat pump outdoor unit shall have an accumulator with accumulator return valve control.
15. The heat pump outdoor unit shall have a high pressure safety switch, high voltage fuses, over-current protection, phase detection protection, thermal fan protection, low pressure protection, compressor overcurrent protection, fan motor voltage protection, current transformer(s), crank case heating, and intelligent logic to ensure proper operation within unit design limitations and operational parameters.
16. The Inverter compressor driver PCB(s) shall cooled with liquid refrigerant circuit(s) to operate at optimal temperatures and to prevent failure due to overheating. No compressor inverter PCB’s will be cooled by air over heat sink. Cooling inverter components without air-cooling fins prevents failure due to environmental contaminants.
17. The heat pump outdoor unit shall be capable of operating in cooling mode between 23°F ~ 120°F outside ambient temperatures.
18. The heat pump outdoor unit shall be capable of operating in cooling mode below 23°F down to 5°F outside ambient temperature with the addition of LACH side and rear guards.
19. The heat pump outdoor unit shall be capable of operating in cool mode down to -13°F ambient temperatures with use of low ambient cooling hood (LACH-1, LACH-2) and side/rear guards.

20. The heat pump outdoor unit shall be capable of operating in heating mode between -13°F ~ 75°F ambient temperatures.
21. The heat pump system shall allow adjustment of target evaporator coil temperatures in cooling mode and target heating discharge pressures depending on project conditions for heating and cooling calibration thus saving energy.
22. The heat pump outdoor unit shall have a high efficiency, individual oil separators for each compressor plus additional logic controls to ensure adequate oil volume in the compressor is maintained.
23. The heat pump outdoor unit shall have a flat-plate type subcooler to sub cool liquid refrigerant further to increase capacity and performance with long pipe lengths and to decrease refrigerant sounds at indoor equipment.
24. The compressors shall have flash injection capability to increase performance in heating mode. This will be automatically enabled by the outdoor unit(s) by forcing saturated refrigerant as a liquid flash mix directly into the scroll compression cycle increasing mass flow and overall system capacity. Compressors without flash injection shall not be present in the VRF heat pump system.
25. The heat pump outdoor unit shall have a removable EEPROM at the main PCB to store all unit data. All data on the outdoor unit EEPROM shall be viewable from the manufacturer provided service software. The outdoor unit main EEPROM shall be removable allowing replacement of outdoor unit PCB without losing digital, field programmed data. The outdoor unit removable EEPROM shall store the following unit data: unit model number, unit serial number, unit main PCB firmware and MICOM version, sub-PCB firmware and MICOM version, fan PCB firmware and MICOM version, inverter PCB 1 and inverter PCB 2 firmware and MICOM version, auto-trial commissioning startup data, the last 30 minutes of operation data, and field programmed unit name/tag viewable on controls and service software.
26. The heat pump outdoor unit shall have the ability to discharge inverter PCB capacitor voltage using service buttons on the outdoor unit main PCB. The capacitor stored-voltage discharge feature shall allow safe inverter PCB replacement.
27. The heat pump outdoor unit shall have outdoor unit pump-down operation capability allowing storage of refrigerant while opening sealed refrigerant pipe system outside of outdoor unit chassis while performing service. The outdoor unit refrigerant storage shall be greater than the supplied factory R-410A charge.
28. The heat pump outdoor unit shall have individual outdoor module pump-out operation capability allowing the majority of refrigerant in an outdoor unit to be pumped out. The pump-out feature shall allow service of sealed refrigerant system within an outdoor unit chassis.
29. The heat pump outdoor unit shall allow temporary disabling of individual compressors to allow system operation at reduced capacity after a compressor or compressor component related issue (when more than one compressor is present in system). Disabling of a compressor shall temporarily remove error codes and allow system operation.
30. The heat pump outdoor unit compressors shall have a soft-start function to reduce electricity demand during system start and to increase compressor reliability.
31. In the event of system error due to outdoor unit failure, the heat pump outdoor unit shall display codes that specify a precise error and which outdoor unit PCB is the cause.
32. The heat pump system shall support system auto-addressing allowing system commissioning without manually configuring indoor unit addresses.
33. Electrical:
    a. The outdoor unit electrical power shall be 208/230 volts, 3 phase, 60 hertz.
    b. The 208/230 VAC unit shall be capable of satisfactory operation within voltage limitations of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).
    c. The outdoor unit shall be controlled by integral microprocessors.
    d. The control circuit between the indoor units and the outdoor unit shall be 0.5VDC - 7VDC completed using stranded, annealed copper conductor, 16 AWG, shielded, two-core cable to provide total integration of the system.

2.5 ACCESSORIES

A. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

1. General: The DVM Controls Network Solution shall be capable of supporting remote controllers, schedule timers, system controllers, centralized controllers, an integrated web based interface, graphical user workstation, and system integration to Building Management Systems via BACnet®.
2. Electrical Characteristics: The DVM S Controls Solution shall operate at 12V DC. Controller power and communications shall be via a common communications bus.
3. Wiring:
   a. Main system control wiring (COM1, F1/F2) shall be installed in a system daisy chain configuration from the indoor equipment to MAIN outdoor unit. This cable shall be 16 AWG X 2, shielded cable.
   b. Zone control wiring (COM2, F3/F4) to wired remote controllers shall be run from the indoor unit terminal block to the controller associated with that unit. This cable shall be 16 AWG X 2, shielded cable.
4. Wiring type:
   a. COM1 and COM2 control wiring shall be 2-conductor, 16 AWG X 2, shielded cable.
   b. Network wiring shall be CAT-5e with RJ-45 connection.

B. Thermostat (MULTI-FUNCTION CONTROLLER – PREMIUM INDIVIDUAL WIRED CONTROLLER):

1. The wired controller shall control indoor units and as follows:
   a. Air handler operation ON/OFF
   b. Air handler operation mode, set temperature, air flow direction, fan speed, individual louver control (with supported indoor units), discharge air temperature (with supported indoor units)
   c. Quiet and sleep modes
   d. Error display
   e. Filter replacement alarm display and reset
   f. Single indoor unit control or multiple unit control (maximum 16 units)
2. Energy saving operation:
   a. Upper/lower temperature setting
   b. Automatic operation stop function
   c. Energy saving operation mode
   d. Weekly operating schedule and setting
   e. Desired A/C operation mode, setting temperature, power mode (ON/OFF), and fan speed to operate based on weekly or daily schedules
   f. Different button permission levels
   g. Partial button lock (on/off, selection, temperature setting, fan speed, and schedule setting buttons can be locked individually)
   h. Backlight
   i. Daylight savings clock advance
   j. Upper and lower temperature setting restriction
   k. Auto mode skip
   l. Heat mode skip (cooling only)
   m. Louver position setting (cassette)
   n. Individual air direction control for 360 Cassette indoor units.
   o. Auto-off option to automatically turn the associated indoor unit(s) off after the specified time without any interaction with the wired controller
   p. System/indoor unit function and operation indication (defrost, error, restricted controller, SPi status)

q. Service mode for connected indoor unit operation monitoring, addressing, and setup
r. Real-time clock function - current time/day display function
s. Built-in room temperature sensor
t. Indoor unit operation state display
u. Service mode support (Indoor unit addressing, indoor unit cycle data monitoring, option code monitoring and setting, and option setting/monitoring)
v. Wind-Free™ display and control for supported indoor unit models
w. Motion Detection Sensor Control (On/Off, Indirect/Direct) for supported indoor unit models

C. BACnet® GATEWAY 2.5
1. Function:
a. The BACnet® gateway shall have basic operation controls which can be applied to an individual indoor unit, a group of indoor units (up to 256 indoor units), or all indoor units (collective batch operation). This basic control set of operation controls for the BACnet® gateway shall include on/off, operation mode selection (auto, cool, heat, dry, and fan), temperature setting, fan speed setting, airflow direction setting, error email notification, temperature limitations, operation mode limitation, and online maintenance.
b. The BACnet® gateway shall support system error notification via email. The Data Management Server emailed errors shall include: error occurrence time, error code with description of error, effected equipment address, and current error status.
c. The BACnet® gateway shall support: system configuration, 1-day/daily/weekly scheduling, monitoring of operation status, online maintenance tool, operation superseding of the remote controllers, editable user defined control logic, and malfunction monitoring.
d. Schedule Control Function through web browser. Up to 256 schedule settings, weekly and daily schedule setting, wireless/wired remote controller restriction setting. Digital Outputs can be incorporated into scheduling.
e. The Server shall allow configuration of unoccupied room settings for indoor units configured for unoccupied room control.
f. Convenient digital display allows for easy set up.
g. SD memory card slot for data storage and software updating.
h. Available programmable logic to control the system based on preset monitor points. Specify various system control point inputs (indoor units, outdoor units, DI, DO) and operators ($=$, $>$, $<$, $\leq$, $\geq$, $\neq$) to manipulate system operation (indoor units, outdoor units, DI, DO) based on the status of the specified variables.
i. "Weighted averaging" or "representative" setting for heat pump systems to provide optimal auto changeover while in Auto mode.
j. Web Server Function with remote control (with a public IP address) via internet connection. No management software required – PC-independent management through web browser.
k. 10 DI (Digital Input) ports available. Two digital input ports shall be for emergency shutdown with external contact control interface and 8 for other monitoring options (OPEN/CLOSE status). Full indoor unit control with simple contact input (Emergency/Lock). Digital inputs can be incorporated into control logics.
l. 8 DO (Digital Output) terminals for monitoring and control options. 2 state output (Operation/Error) for synchronous control and monitoring. 6 general purpose outputs to control other components (on: 12VDC out; off: no voltage). Digital Outputs can be incorporated into control logics and scheduling.

D. Automatic-reset timer to prevent rapid cycling of compressor.

E. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

F. Drain Hose: For condensate.

G. Monitoring:

1. Monitor constant and variable motor loads.
2. Monitor variable-frequency-drive operation.
3. Monitor economizer cycle.
4. Monitor cooling load.
5. Monitor air distribution static pressure and ventilation air volumes.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Equipment Mounting:

1. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base(s).
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

D. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

C. Duct Connections: Duct installation requirements are specified in Section 233113 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Section 233300 "Air Duct Accessories."

3.3 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, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.5 DEMONSTRATION

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

END OF SECTION 23 81 26

SECTION 26 05 00

COMMON WORK RESULTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes requirements for basic materials and methods for electrical work specified in Division 26 of these Specifications.

B. Furnish and install electrical systems, cable, equipment and accessories in accordance with the technical specifications and the Drawings. Capacities, sizes and ratings of conduits, pull boxes, lighting, cable, panel boards, other items, and arrangements for electrical items in general are shown on the Drawings and specified herein.

C. The scope of work includes:

1. Furnishing and installing electric service equipment as indicated on the Drawings and specified herein;
2. Furnishing and installation of conduits and pull boxes from the distribution panels and pull boxes to locations of devices or stub-us as shown on the Drawings;
3. Furnishing, installing and wiring of the power panels and emergency lighting power supply, including distribution panels and utility meter as shown on the Drawings and specified herein;
4. Furnishing and installation, including termination, of conductors from service point to irrigation controller cabinets, and to all devices including TVMs (Ticket Vending Machines), CIDs (Card Interface Devices), PIMs (Passenger Information Monitors) and ETELs (Emergency Telephones) as shown on the Drawings;
5. Furnishing and installing lighting equipment for Street Lighting, Eastridge Transit Center Lighting, Tail Track Lighting, Pedestrian lighting, Station Lighting including shelter lighting, platform lighting and Pedestrian Over Crossing (POC) lighting as shown on the Drawings;
6. Furnishing, installing and programming of lighting control equipment as shown on the Drawings and specified herein;
7. Furnishing, installation and wiring of the disconnect switches as shown on the Drawings;
8. Furnishing, installation and wiring of lighting, receptacles, card access system and HVAC controls in enclosed rooms including the electrical room, elevator equipment room, maintenance and storage closet.
9. Furnishing and installing of Fiber Optic System as shown on the Drawings and specified herein;
10. Furnishing and installing of Fire Alarm System as shown on the Drawings and specified herein;
11. Designing, furnishing and installing Photovoltaic (Solar Power) equipment as shown on the Drawings and specified herein;
12. Furnishing and installation of permanent tagging of installed cables at both ends of terminated wires;
13. Furnishing and installation of all other miscellaneous equipment and materials such that the system shall operate to satisfy all design criteria specified herein and shown on the Drawings.
14. Testing of the complete systems.

15. Commissioning and training of complete system.

1.02 RELATED SECTIONS

A. Section 6, Special Conditions

B. Section 7, General Conditions

C. Section 01 11 00, Summary of Work

D. Section 01 55 26, Traffic Control

E. Section 01 57 23, Temporary Storm Water Pollution Control

F. Section 01 71 13, Mobilization

G. Section 01 74 12, Cleaning

H. Section 01 74 15, Dust Control

I. Section 01 78 39, Project Record Documents

J. Section 10 14 53, Roadside Signage

K. Section 02 41 00, Demolition

L. Section 31 00 00, Earthwork

M. Section 31 23 33, Trenching and Backfill

N. Section 26 05 19, Low Voltage Electrical Power Conductors and Cables

O. Section 26 05 26, Grounding And Bonding For Electrical Systems

P. Section 26 05 29, Supports for Electrical Systems

Q. Section 26 05 33, Conduits And Boxes For Electrical Systems

R. Section 26 05 48, Seismic Controls For Electrical Systems

S. Section 26 05 53, Identification for Electrical Systems

T. Section 26 05 73, Power System Study

U. Section 26 09 23, Lighting Control System

V. Section 26 22 00, Dry Type Transformers

W. Section 26 24 16, Panelboards

X. Section 26 27 26, Wiring Devices

Y. Section 26 28 16, Disconnect Switches

Z. Section 26 31 01, Photovoltaic System

AA. Section 26 33 33, Emergency Lighting Power Supply

BB. Section 26 50 00, Lighting

CC. Section 27 15 23, Fiber Optic System

DD. Section 28 46 00, Fire Alarm System

1.03 DESCRIPTION OF BID ITEMS

A. **Story Station Electrical Work:** The contract lump sum price paid for Story Station Electrical Work shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all the work involved in furnishing, installing, wiring and testing electrical service equipment, distribution panels, utility meters, fire alarm system, station lighting including shelter lighting, platform lighting and Pedestrian Overcrossing (POC) lighting; termination of conductors to Ticket Vending Machines (TVM), Card Interface Devices (CID), Passenger Information Monitors (PIM), and Emergency Telephones (ETEL); and programming of lighting control equipment; complete in place as shown on the plans, as specified in these Technical Specifications, and as directed by the Engineer.

B. **Eastridge Station Electrical Work:** The contract lump sum price paid for Eastridge Station Electrical Work shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all the work involved in furnishing, installing, wiring and testing electrical service equipment, distribution panels, utility meters, station lighting including shelter lighting and platform lighting; termination of conductors to Ticket Vending Machines (TVM), Card Interface Devices (CID), Passenger Information Monitors (PIM), and Emergency Telephones (ETEL); and programming of lighting control equipment; complete in place as shown on the plans, as specified in these Technical Specifications, and as directed by the Engineer.

C. **Eastridge Transit Center Lighting:** The contract lump sum price paid for Eastridge Transit Center Lighting shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all the work involved in relocating VTA Pedestrian Light; removing VTA Pedestrian Light; and furnishing, installing and testing Tail Track Lighting and Transit Center parking lighting and cameras including conduit and wire, complete in place, as shown on the plans, as specified in these Technical Specifications, and as directed by the Engineer.

D. **Street Lighting (City):** The contract lump sum price paid for Street Lighting (City) shall include full compensation for furnishing all the labor, materials, tools, equipment, and incidentals and for doing all the work involved in furnishing, installing and testing street lighting, including conduit and wire, complete in place, as shown on the plans, as specified in these Technical Specifications, and as directed by the Engineer.

1.04 MEASUREMENT AND PAYMENT

A. Measurement: Story Station Electrical Work**,** Eastridge Station Electrical Work, Eastridge Transit Center Electrical Work and Street Lighting (City) shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Story Station Electrical Work, Eastridge Station Electrical Work, Eastridge Transit Center Electrical Work and Street Lighting (City) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing Story Station Electrical Work, Eastridge Station Electrical Work, Eastridge Transit Center Electrical Work and Street Lighting (City) complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

C.

1.05 REFERENCED STANDARDS

A. The following codes and standards shall govern the work. Where differences or conflicts arise between codes and/or standards, the latest and most stringent requirements shall apply:

1. County of Santa Clara Standard Specifications, May 2000 and Amended January 7, 2011, and Standard Details, September 1997, and Amended December 21, 2010.
2. City of San Jose, Standard Specifications for Public Works Construction, 1992 http://www.sanjoseca.gov/publicWorks/Details_Specs/:
   a. Section 1, Definition and Terms

b. Section 21, Subgrade Preparation

c. Section 26, Aggregate Bases

d. Section 39, Asphalt Concrete

e. Section 52, Reinforcement

f. Section 73, Concrete Curbs and Sidewalks

g. Section 86, Signals, Lighting and Electrical Systems

h. Section 90, Portland Cement Concrete

3. City of San Jose, Standard Details for Public Works Construction, 1992 http://www.sanjoseca.gov/publicWorks/Details_Specs/:

a. General

b. Roadway Geometrics

c. Electrical - Signals and Lighting

4. State of California, Department of Transportation (Caltrans) Standard Plans and Specifications, refer to http://www.dot.ca.gov/hq/esc/oe/specsifications/std_specs/2018_StdSpecs/2018_StdSpecs.pdf Standard Specifications, 2018

a. Section 21, Subgrade Preparation

b. Section 26, Aggregate Bases

c. Section 51, Concrete Structures

d. Section 52, Reinforcement

e. Section 73, Concrete Curbs and Sidewalks

f. Section 86, Electrical Work

g. Section 87, Electrical Systems

h. Section 90, Portland Cement Concrete

5. National Electrical Code (NEC, 2014):

a. Chapter 1, General

b. Chapter 2, Wiring and Protection

c. Chapter 3, Wiring Methods and Materials

d. Chapter 4, Equipment for General Use

e. Chapter 9, Tables

6. State of California Public Utilities Commission (CPUC) G.O. 128: Construction of Underground Electrical Supply and Communications Systems, Rules For; and CPUC G.O. 95: Overhead Line Construction, Rules For.

7. National Electrical Manufacturers Association (NEMA)

8. Insulated Cable Engineering Association (ICEA)

9. American Society of Testing and Materials (ASTM)

10. Institute of Electrical and Electronic Engineers (IEEE)

B. Standard Specification section numbers referenced in the City Of San Jose Standard Specifications are in accordance with the 1988 Caltrans Standard Specifications and shall be understood to reference the 2018 Caltrans Standard Specifications sections with the revised and updated section numbers.

C. In case of conflict between the National Electrical Code and Cal. PUC G.O. 128, the provisions of Cal. PUC G.O. 128 shall prevail.

D. Materials and equipment shall be listed, labeled or certified by a nationally recognized testing laboratory. Equipment of a class which no nationally recognized testing laboratory accepts, certifies, lists, labels, or determines to be safe, shall be considered if inspected or tested in accordance with National Industrial Standards, such as National Electrical Manufacturers Association (NEMA), or American National Standards Institute (ANSI). Evidence of compliance shall include certified test reports and definitive shop drawings.

1.06 SYSTEM DESCRIPTION

A. Provide street and pedestrian lighting systems as indicated on the drawings, and specified in Section 86 of the City Of San Jose Standard Specifications and herein.

B. SINGULAR NUMBER: Where any device or part of equipment is referred to in these specifications in the singular number (such as "the switch"), such reference shall be deemed to apply to as many such devices as are required to complete the installation as shown on the Drawings.

1.07 SUBMITTALS

A. Submittals' General Requirements:

1. Refer to Special Conditions, Section 6.6 Contract Data Requirements, and Table B-2, Technical Submittals List, and General Conditions, GC-7.41, Product Options, Supplier Approval and Substitutions; GC-7.43, Submittal of Shop Drawings, Product Data and Samples.

B. Retain all manufacturer documentation and warranty information accompanying the installed equipment and materials. Documentation and warranty information shall be submitted to the Engineer upon request, but not later than the date when the installation is complete.

C. Refer to specific submittal requirements included in each of the other sections of Division 26, Sections 27 15 23 and 28 46 00.

D. Provide electronic submittals in pdf format.

E. If deviating from the specified product or method, describe equivalent and methods.

1.08 QUALITY ASSURANCE

A. Products shall be tested, approved and labeled/listed by Underwriters Laboratories, Inc., or by a nationally recognized testing laboratory (NRTL).

B. Electrical equipment and materials shall be new and within one year of manufacture, complying with the latest codes and standards. No used, re-built, refurbished and/or re-manufactured electrical equipment and materials shall be furnished on this project.

C. Regulatory Requirements: Inspection by City, County, VTA and Other Governing and Regulatory Authorities: Contractor shall allow the City of San Jose, and other governing and regulatory authorities to perform testing and inspection of materials and practices associated with construction within their jurisdiction on the Worksite during business hours for the purpose of ensuring that the Work is in compliance with requirements of the City Code and other local, State and Federal laws and regulations.

D. Qualifications:

1. The manufacturer shall regularly and presently produce, as one of the manufacturer's principal products, the equipment and material specified for this project, and shall have manufactured the item (except street light luminaire) for at least three years.

2. Contractor shall have experience in the construction of street lighting within the City of San Jose.

E. Contractor shall provide a Certificate of Compliance from the manufacturer of all equipment and materials in accordance with the provisions of GC-7.49, Certificates of Compliance and Testing, of the General Conditions.

F. Certifications: Contractor to provide qualification testing and certification for acceptance of materials, components and assemblies.

G. Testing: Contractor to provide control testing of in-progress work being performed in shops, factories and on-site.

H. Inspection: Contractor to provide on-site inspection of specified work elements.

1.09 DELIVERY, STORAGE AND HANDLING

A. Packing, shipping, handling and unloading:

1. Materials except for poles, anchor bolts, pull boxes and lids shall be delivered on site in original containers or factory packaging and inspected for damage;

2. Containers and packaging shall be labeled with manufacturer's identification, including catalogue number, size, type, density, thickness, and nationally recognized body(ies), e.g. UL, CSA, ASTM, NEMA, etc.;

3. Handle in accordance with manufacturer’s written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to internal components, enclosure and finish.

B. Storage and protection:

1. Containers and packaging protect materials from weather and construction traffic, dirt, water, chemical, and mechanical damage.

2. Protect equipment and material during shipment and storage against physical damage, dirt, moisture, cold and rain.

C. Additional requirements per Section 6.10, Delivery, Unloading and Storage.

1.10 PROJECT/SITE CONDITIONS

A. Additional requirements per Section 02 41 00, Demolition, and per Section 01 74 12 Cleaning.

1.11 SEQUENCING

A. Arrange, phase and perform work to ensure coordination with other trades. The Contractors attention is directed to the requirements for fencing and grade restoration.

1.12 SCHEDULING

A. Additional requirements per Section 6.21, Progress Schedule.

1.13 WARRANTY

A. Refer to Section 7- General Conditions for general warranty requirements. The warranty requirements specified herein are in addition to the General Conditions warranty provisions.

B. During the warranty period, Contractor shall ensure that technical support is available from the supplier via telephone within four hours of the time a call is made by VTA, and that this support is available from factory certified personnel or factory certified installers.

C. Pursuant to GC-7.73, "Warranty," Contractor shall be responsible for providing all warranties for lighting wire installation in conduit, for meeting all lighting testing requirements by the City of San Jose, VTA, and the Standard Specifications, and for associated rework necessary to meet these requirements. Upon request, Contractor shall provide written documentation of successful experience within the last five years.

1.14 MAINTENANCE

A. Maintenance Services: The Contractor shall maintain all systems installed under this contract until final acceptance by the Engineer. Fixtures that have been put in service under this contract and then fail to operate before final acceptance shall be repaired by the Contractor within two working days. If the Contractor fails to make repairs on time without just cause, the VTA may make repairs and deduct the cost of the repairs from payment due the Contractor.

PART 2 - PRODUCTS

2.01 GENERAL

A. The Contractor shall furnish all materials, tools, equipment, devices, appurtenances, facilities, and services as required for performing the electrical systems work.

B. All hardware, fasteners, nuts, bolts, washers, straps shall be hot dipped galvanized unless noted otherwise.

2.02 MANUFACTURED PRODUCTS (UNITS)

A. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, and for which replacement parts shall be available.

B. When more than one unit of the same class of equipment is required, such units shall be the product of a single manufacturer.

C. Factory wiring shall be identified on the equipment being furnished and on all wiring diagrams.

D. Equipment Assemblies and Components:

1. Components of an assembled unit need not be products of the same manufacturer;
2. Manufacturers of equipment assemblies, which include components made by others, shall assume complete responsibility for the final assembled unit;
3. Components shall be compatible with each other and with the total assembly for the intended service;
4. Constituent parts, that are similar, shall be the product of a single manufacturer.

2.03 EQUIPMENT PROTECTION

A. During installation, protect equipment, controls, circuit protective devices, and other like items against entry of foreign matter; and vacuum clean both inside and outside before testing, and operating.

B. Damaged equipment shall be, as determined by the Engineer, placed in original operating condition or be returned to the source of supply for repair or replacement, at no additional cost to the VTA.

C. Painted surfaces shall be protected with factory installed removable protective paper, sheet vinyl or equal.

D. Refinish damaged paint on equipment and materials with the same quality of paint and workmanship as used by the manufacturer so repaired areas are not obvious, at no additional cost to the VTA.

2.04 EQUIPMENT IDENTIFICATION

A. In addition to the requirements of the NEC, install an identification sign which will clearly indicate information required for use and maintenance of items such as panel boards, cabinets, enclosed circuit breakers, individual breakers, control devices and other significant equipment.

B. Nameplates shall be laminated black phenolic resin with a white core with engraved lettering, a minimum of 3/16 inch high. Nameplates that are furnished by manufacturer as a standard catalog item, or where other method of identification is herein specified, are exceptions.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify locations and condition of existing electrical/PG&E facilities that are to be connected to, that may affect the electrical systems as shown on the drawings, or may otherwise be affected by the work, and report all discrepancies to the Engineer in writing.

B. Indicate on the drawings any revisions in order to proceed with the electrical systems as designed and allow 5 days for review and approval by the Engineer prior to doing work under this Section.

C. Contractor shall, by constructing any facility specified in this Section, guarantee to VTA that he has checked for all conflicts with known existing facilities, or facilities subsequently discovered by the Contractor in the field, or new improvements as shown on the drawings, and that no conflicts exist.

D. Before commencement of street lighting work, Contractor shall carefully inspect the existing conditions, review the work of the Contract which interfaces with street lighting work and verify such work is correct and complete.

E. Contractor shall verify and locate existing equipment to confirm that it matches the Drawings.

F. Contractor shall immediately notify the Engineer of any discrepancy regarding work by others and existing conditions before proceeding with work.

3.02 PREPARATION

A. Locate existing facilities, pothole, and maintain existing utilities as specified in Section 31 00 00, Earthwork.

3.03 EQUIPMENT INSTALLATION AND REQUIREMENTS

A. Equipment location shall be as close as practical to locations shown on Drawings.

B. Working spaces shall not be less than specified in the NEC for all voltages specified.

C. Grounding shall be in accordance with Section 26 05 26, Grounding and Bonding for Electrical Systems.

D. Electrical power cabinet components wired by Contractor shall be tested for continuity and functional operation as designed.

E. All equipment shall be installed in accordance with manufacturer's instructions.

3.04 CONSTRUCTION

A. Salvage, deliver, and stockpile CSJ facilities, including luminaires, poles, and bracket arms, in accordance with Section 02 41 00, Demolition and Removals.

3.05 PROTECTION

A. Contractor shall protect adjacent existing site improvements from damage during installation procedures

3.06 SCHEDULES

A. Additional requirements per Section 6, Special Conditions - 6.21 Progress Schedule.

END OF SECTION 26 05 00

SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing and installing the following conductors and appurtenances:

1. Furnishing and installing, including termination, of conductors from service interface to street lights, pedestrian lights, Eastridge transit center lights, station lights including Pedestrian Overcrossing at Story Station, substation lighting, tail track lighting and irrigation controller cabinets via service cabinets or any other type of service point;

2. From utility meter panel to electrical distribution panel and to all equipment, lights and receptacles on the stations and to other electrical devices included in the scope of the individual stations.

B. Electrical work for the irrigation control circuits fed from the irrigation controller cabinet is covered in Section 32 84 00, Planting Irrigation.

1.02 MEASUREMENT AND PAYMENT

A. Full compensation for work under this section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefor.

1.03 REFERENCES

A. City of San Jose Standard Specifications (CSJSS), Sections 86-2.07 through 86-2.11

B. City of San Jose, Standard Details for Public Works Construction, 1992; Electrical - Signals and Lighting http://www.sanjoseca.gov/publicWorks/Details_Specs/

C. ASTM B33-10 Standard Specifications for Tin-Coated, Soft or Annealed Copper Wire

D. Underwriters' Laboratories, Inc. (UL): standards for power distribution equipment

E. National Electrical Code (NEC)

F. National Electrical Manufacturers Association (NEMA)

G. Insulated Cable Engineering Association (ICEA)

H. State of California Standard Specifications

I. Institute of Electrical and Electronic Engineers (IEEE)

1.04 SUBMITTALS

A. Refer to Section 26 05 00 1.06, Submittals.

B. Submit a list of all equipment and materials, and product data sheets of all materials intended for use to Engineer for approval prior to start of work.

C. Prior to installation, the following information for each cable segment to be installed:

1. Cable pulling data, including distances and tension calculations;

2. Cable pulling equipment and tension monitoring devices; and

3. Installation plan, including estimated time for each segment pull, and plan for protection of cable during installation.

D. Log of field tests.

E. "Redlined" drawings showing final cable numbering, routing and spare conduits.

1.05 PROJECT/SITE CONDITIONS

A. Project/Site Environmental Conditions

1. Verify that field measurements are as shown on Drawings.
2. Wire and cable routing shown on Drawings is approximate. Route wire and cable as required for Project conditions.
3. Where wire and cable routing is not shown, and destination only is indicated, determine exact routing and lengths required.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. THW 600 Volt, Copper by Service Wire Co. or approved equal
2. ULT Copper C Crimps by Ilsco or approved equal
3. Spring Connectors Scotchlok B by 3M or approved equal
4. Color-Keyed C Taps 600V Applications by Thomas & Betts or approved equal
5. CFW Heavy Wall Heat Shrinkable Tubing by DSG-Canusa or approved equal
6. Tape Sealant CTSB-2 by DSG-Canusa or approved equal
7. Scotch Super 33+ vinyl electrical tape or approved equal
8. Scotch Linerless Rubber Splicing Tape 130C by 3M or approved equal
9. Scotchkote Electrical Coating by 3M or approved equal
10. Temflex 1700 Vinyl Electrical Tape by 3M or approved equal

2.02 MATERIALS

A. WIRE AND CABLE

1. Description: Single conductor insulated wire.
2. Conductor: Copper. Use solid conductor for feeders and branch circuits No. 10 AWG and smaller.
3. Insulation Voltage Rating: 600 Volts. Insulation: Type THW. Use of THW conductor with insulation thickness as specified by the N.E.C., and U.L. Standard, is acceptable for this project. Branch circuits may use conductors with Type THWN insulation.
4. Power conductors that are run with communication cables in the light poles shall be UL type MC interlocked armor. The armor shall be galvanized steel. The conductors shall be copper with XLPE insulation. An extruded black PVC, sunlight resistant jacket shall be applied over the interlocking armor.

B. TAGS

1. Weatherproof, non-conducting, permanent wire and cable tags, Partex PFM marking system or equal.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Site Verification of Conditions

1. Verify that mechanical work likely to damage wire and cable has been completed.

3.02 PREPARATION

A. The conduit and pull boxes shall be installed complete before conductors are installed.

B. Swab conduits completely and thoroughly before installing wire.

3.03 INSTALLATION

A. Special Techniques

1. Products shall be installed in accordance with manufacturer's instructions. All wiring shall be installed by hand, without the use of winders or other power actuated pulling equipment, unless specifically approved by the Engineer.

2. Neatly train and lace wiring inside boxes, equipment, poles and service cabinets.

3. Crossover of conductors shall be avoided when conductors are pulled into conduits. Care shall be taken not to have the conductors pulled tight or kinked in conduit, fittings or boxes. All cables to be installed in a single conduit shall be pulled and installed simultaneously.

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

5. Splices shall be insulated by "Method B."

6. At least 24 inches of slack shall be left for each conductor at each street lighting standard, and at least 5 feet of slack at each pull box unless otherwise noted. Slack shall be measured by determining the maximum distance away from the top of the pull box or edge of pole hand hole frame that the conductor may be extended from the pull box or pole.

B. Interface with Other Work

1. Ground conductors shall be installed in all conduits with new conductors.

C. Sequence of Operation

1. Protect exposed conductors from damage.

2. Clean conductor surfaces before installing on lugs and connectors.

D. Site Tolerances

1. No conductor smaller than that shown on Drawings shall be used.

2. Compression type terminals, screw type ring tongue or locking fork terminal lugs shall terminate all power, communication and control cables.

3. Immediately after cable or wire installation, seal all conduit ends with an approved conduit sealant manufactured for this purpose.

E. Cable Identification

1. Install permanent cable tags at both ends of each cable. Each tag shall identify the origin and destination of the cable and the number and sizes of conductors. Install permanent wire tags at all conductor terminations, including spares. Tags shall provide a unique identification of origin and destination of the conductor and its circuit number.

2. Ground conductors shall have green insulation or be bare copper.
3. Wire designations shall consistently conform to an overall scheme prepared by Contractor and approved by the Engineer to indicate location, circuit, device, wire number, terminal branch, position, etc. Letters and numbers shall be used.
3. Neutral conductors shall have white insulation.
4. Phase conductors from single pole circuit breakers shall have insulation with a variety of colors (non-white and non-green) to provide unique identification.

3.04 RE-INSTALLATION

A. New conductors shall be provided whenever conductors must be re-installed.

3.05 FIELD QUALITY CONTROL

A. Site Tests
1. Log all testing including location, type of test, conductor description, and test result.
2. Inspect wire and cable for physical damage and proper connection.
3. Measure tightness of bolt or screw connections and compare torque measurements with manufacturer's recommended values.
4. Verify continuity of each branch circuit conductor.
5. A 500-volt megger shall be used to determine the insulation resistance to ground. A minimum of five mega-ohms between ground and any conductor shall be maintained.
6. All conductors shall be individually proven to be discrete, free from ground and continuous. Upon completion, tests shall be made for possible damage at the discretion of the Engineer before acceptance.

END OF SECTION 26 05 19

SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes requirements for grounding and bonding of the electrical system. The functions of the grounding systems are to:

1. Protect personnel and equipment from electrical hazards.
2. Minimize the leakage of stray direct current due to improper interconnections between grounded and ungrounded portions of the project.

1.02 MEASUREMENT AND PAYMENT

A. Full compensation for work under this section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefor.

1.03 REFERENCES

A. ASTM B33-10 Standard Specifications for Tin-Coated, Soft or Annealed Copper Wire

B. Institute of Electrical and Electronics Engineers, Inc. (IEEE) 142-2007 (Green Book) Recommended Practices for Grounding of Industrial and Commercial Power Systems

For convenience here is a URL for the IEEE page:

http://standards.ieee.org/findstds/standard/142-2007.html

C. Underwriters' Laboratories, Inc. (UL): standards for power distribution equipment

D. City of San Jose Standard Specifications (CSJSS): Section 86-2.10 Bonding and Grounding

E. City of San Jose, Standard Details for Public Works Construction, 1992; Electrical - Signals and Lighting http://www.sanjoseca.gov/publicWorks/Details_Specs/

F. County of Santa Clara, Roads and Airports, Standard Specifications, May 2000

1.04 SYSTEM DESCRIPTION

A. Design Requirements

1. Effective Grounding Path. The path to ground from equipment and equipment enclosures for conductors shall:
    a. Be permanent and electrically continuous,
    b. Have capacity to conduct safely any fault current to be imposed on it, and
    c. Have sufficiently low impedance to limit the voltage ground and to facilitate the operation of the circuit protective devices.
    d. The earth shall not be used as the sole equipment-grounding conductor.
2. If the Engineer determines that the ground path is not continuous, measures shall be taken to correct this to Engineer’s satisfaction.

1.05 SUBMITTALS

A. Refer to Section 26 05 00, 1.06, Submittals.

B. Submit a list of all equipment and materials, and product data sheets of all materials intended for use to the Engineer for approval prior to start of work.

C. Detailed test procedures for each test, a minimum of 15 days prior to the date of scheduled testing.

D. Certified test reports within seven calendar days of test completion.

1.06 SEQUENCING

A. Schedule electrical ground testing as the Work progresses. Do not defer testing for the purpose of consolidating the testing effort

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide equipment and tools necessary to conduct testing in accordance with the approved test procedures.

1. Meters, Gauges and Other Measuring Equipment: Calibrated within six months of the date of each test.
2. Recalibrate equipment on a regular basis during the life of this Contract to continuously meet this requirement.
3. Provide marking on wire and cable in accordance with the referenced standard.

B. To the degree feasible, use the same testing equipment and test personnel for similar tests during the life of this Contract.

1. Provide marking on wire and cable in accordance with the referenced standard.
2. Each item shall have a label from a nationally recognized testing laboratory.
3. Ship each unit securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.

C. Store equipment in secure and dry storage facility.

2.02 MANUFACTURERS

A. Bare Copper Class B 7 Strand by Anixter or approved equal

B. Direct Burial Bronze Ground Clamps ½”-1” by NSI Grounding or approved equal

C. Range-Taking Ground Rod Clamp 5/8” by NSI Grounding or approved equal

D. BGRC Grd Rod Clamp Cast by Ilsco or approved equal

E. Eritech Copperbonded Ground Rods by Eritech or approved equal

F. Copper Coated Electroplated Ground Rod 941250000 by Nehring Electrical Works or approved equal

G. Blackburn Sectional Type Ground Rods and Fittings 5/8” x 10’ by Thomas & Betts or approved equal

2.03 MATERIALS

A. Grounding : UL 467 with the following additional requirements:

1. Test wells: Cast iron test well for each station ground system, electrical panel ground and communication cabinet ground system as indicated.
2. Ground Rods: Medium carbon steel core, copper-clad by molten weld casting process, UL approved, 10’ long by 5/8” or unless otherwise indicated.

B. Bare Conductors: ASTM B3, Class B stranded annealed copper conductor, unless otherwise indicated, sized as indicated.

C. Single Conductor Insulated Cable: In accordance with Section 26 05 19, Low Voltage Electrical Power Conductors and Cables, size as indicated.

D. Jumpers: Tin-plated, copper, braided, flexible jumper

PART 3 - EXECUTION

3.01 GENERAL

A. Grounding shall be in accordance with the National Electrical Code. Establish reference ground with a connection to a cold water pipe and a connection to driven ground rods and rebar.

B. Make connections to a cold water pipe through mechanical compression type connectors with complete brazing. Make connections to a ground rod, building steel, or rebar through an exothermic weld process. Weld in accordance with manufacturer's requirements. Clean and coat with epoxy before back filling.

C. Electrical equipment and devices shall be permanently and effectively grounded. Install a wiring system ground conductor with the phase conductors. Install bonding for all non-current carrying metal parts of enclosures including to conduit, boxes, and lighting fixtures. Size ground conductors in accordance with the current carrying capacity of the circuit conductors and/or settings of the over-current devices.

D. Ground Rods:

1. Bury ground rods vertically as shown on the Plans. If extensive rock formation is encountered, relocate ground rods as approved by the Engineer.

2. Interconnect ground rods with No. 2/0 AWG copper conductor cable or as indicated on the Plans.

E. Ground metallic conduits and junction boxes, in accordance with the requirements of the NEC.

F. Conduit stub-ups shall be grounded, and where multiple stub-ups are made within an equipment enclosure, such as cabinets and pull boxes, they shall be equipped with grounding bushings and bonded together and to the enclosure and the enclosure ground bus.

G. Provide bonding devices, fittings, or jumpers at expansion fitting, isolation sections, or wherever continuity of ground is broken including knockouts and compression type lock nuts and bushings.

H. Provide a bonding jumper to ground the shelter steel. The points of attachment shall be accessible.

3.02 INSTALLATION

A. Special Techniques

1. City of San Jose Detail E-42 of the Standard Details shall include bonding and grounding between grounding lug and ground rod.

2. Luminaires shall be grounded with a continuous #10 AWG green grounding conductor terminated in the luminaire and connected to the grounding wire in the base of the pole.

3.03 GROUNDING SYSTEM TESTING

A. Prepare site for testing as specified prior to commencement of testing. Conduct testing in accordance with approved procedures. Schedule the testing sufficiently in advance to permit observation by the Engineer. Prepare and submit test reports promptly. Correct deficient installations as indicated and retest. Continue cycle until acceptable results are obtained.

B. Test Procedure:
   1. Required Equipment: Low resistance ohmmeter, Biddle Model 247000 or equal.

C. Test Locations: Test each discrete ground location to determine if the maximum ground rod resistance is less than the specified value.

D. Set Up:

   1. Conduct a visual and "hands on" inspection of the grounding system. Ensure that the construction is complete and stable and that all components are dry and clean. Remove any debris that may create a conductive path.

E. Grind clamping locations on each ground rod.

F. Connect lead cables to ohmmeter in accordance with equipment manufacturer's instructions.

G. Resistance: Resistance to ground shall not exceed five ohms.

END OF SECTION 26 05 26

SECTION 26 05 29

SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing and installing supports for electrical systems:

1. Conduit and cable supports
2. Mounting, anchoring and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts and toggle bolts
3. Formed steel channel
4. Spring steel clips
5. Sleeves
6. Mechanical sleeve seals
7. Firestopping to electrical work
8. Equipment bases and supports

B. Related Requirements:

See Section “Seismic Controls for Electrical Systems” for products and installation requirements necessary for compliance with seismic criteria.

1.02 MEASUREMENT AND PAYMENT

A. Full compensation for work under this section shall be considered as included in the prices paid for the various contract items of work involved and no additional payment will be allowed therefor.

1.03 REFERENCED STANDARDS

A. ASTM

B. National Fire Protection Association

C. Underwriters' Laboratories, Inc. (UL)

1.04 SUBMITTALS

A. Refer to Section 26 05 00.

B. Submit a list of all equipment and materials, and product data sheets of all materials intended for use to the Engineer for approval prior to start of work.

PART 2 - PRODUCTS

2.01 CONDUIT SUPPORTS

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

1. Allied Tube & Conduit Corp or approved equal
2. O-Z Gedney or approved equal

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

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

D. Cable Ties: High strength nylon temperature rated to 85 degrees C. Self locking.

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

2.02 MOUNTING, ANCHORING AND ATTACHMENT COMPONENTS

A. Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
2. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
3. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
4. Toggle Bolts: All steel springhead type.

B. Manufacturers:

1. Hilti, Inc. or approved equal
2. B-Line, an Eaton business or approved equal

2.03 FORMED STEEL CHANNEL

A. Manufacturers:

1. B-Line Systems or approved equal
2. Unistrut Corp or approved equal

B. Product Description: Galvanized 0.1 inch thick steel, with holes 1.5 inch on center.

2.03 SPRING STEEL CLIPS

A. Product Description: Mounting hole and screw closure.

2.04 SLEEVES

A. Sleeves through Non-fire Rated Walls and Footings: Steel pipe

B. Sleeves through Fire Rated and Fire Resistive Floors and Walls: Prefabricated fire rated sleeves including seals, UL listed.

2.05 FIRESTOPPING

A. 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.

B. General:

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

C. 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

3.01 EXAMINATION

A. Verify existing conditions before starting work.

B. Verify openings are ready to receive sleeves.

C. Verify openings are ready to receive firestopping.

3.02 PREPARATION

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

B. Obtain permission from Engineer before drilling or cutting structural members.

3.03 INSTALLATION

A. Anchor and Fasteners:

1. Concrete Structural Elements: Provide precast inserts, expansion anchors and preset inserts.
2. Steel Structural Elements: Provide beam clamps, 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. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
3. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

C. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

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

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

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 every 30 foot.

G. Firestopping:

1. Install material at fire rated construction perimeters and openings containing penetrating sleeves, piping, ductwork, conduit and other items, requiring firestopping.
2. Apply primer where recommended by manufacturer for type of firestopping material and substrate involved, and as required for compliance with required fire ratings.
3. Place foamed material in layers to ensure homogenous density, filling cavities and spaces. Place sealant to completely seal junctions with adjacent dissimilar materials.
4. Remove dam material after firestopping material has cured.
5. Fire Rated Surface:
   a. Seal opening at wall and ceiling as follows:
      i. Install sleeve through opening and extending beyond minimum of 1” on both sides of building element.
      ii. Size sleeve allowing minimum of 1” void between sleeve and building element.
      iii. Pack void with backing material.
      iv. Seal ends of sleeve with UL listed fire resistive silicone compound to meet fire rating of structure penetrated.
   b. Where conduit penetrates fire rated surface, install firestopping product in accordance with manufacturer's instructions.
6. Non-Rated Surfaces:
   a. Install escutcheons 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.
   b. 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.
   c. Interior partitions: Seal pipe penetrations at signal and communication rooms. Apply sealant to both sides of penetration to completely fill annular space between sleeve and conduit.

H. Equipment Bases and Supports:

1. Provide housekeeping pads of concrete, minimum 4 inches thick and extending 6 inch beyond supported equipment.
2. Using templates furnished with equipment, install anchor bolts, and accessories for mounting and anchoring equipment.
3. Install anchor bolts to elevations required for proper attachment to supported equipment per manufacturer’s written instructions.

I. Sleeves:

1. Exterior watertight entries: Seal with adjustable interlocking rubber links.
2. Conduit penetrations not required to be watertight: Sleeve and fill with silicon foam.
3. Set sleeves in position in forms. Provide reinforcing around sleeves.
4. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.

5. Extend sleeves through floors 1 inch above finished floor level. Caulk sleeves.
6. 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.
7. Install chrome plated steel, plastic, stainless steel escutcheons at finished surfaces.

3.04 FIELD QUALITY CONTROL

A. Execution and closeout, field inspecting, testing, adjusting, and balancing shall be in accordance with the general conditions.

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

3.05 PROTECTION OF FINISHED WORK

A. GC-7.52,"Protection of Completed Portions of Work".

B. Protect adjacent surfaces from damage by material installation.

END OF SECTION 26 05 29

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SECTION 26 05 33
CONDUITS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing and installing underground pull boxes and junction boxes for electrical power, lighting (Street lighting, Transit center lighting, Station lighting including shelter lighting, platform lighting and Pedestrian Over Crossing lighting), communications and irrigation controllers.

B. Raceway and wireway used for lighting (Street lighting, Transit center lighting, Station lighting including shelter lighting, platform lighting and Pedestrian Over Crossing lighting), communications and irrigation.

C. Pull boxes for wiring fed from irrigation controllers are covered in Section 32 84 00, Planting Irrigation.

1.02 REFERENCED STANDARDS

A. Pacific Gas and Electric Company (PG&E) Electric and Gas Service Requirements (PG&E Green Book)

B. City of San Jose Standard Specifications (CSJSS): Section 86-2.06, Pull Boxes

C. City of San Jose, Standard Details for Public Works Construction, 1992; General, Roadway Geometrics, and Electrical - Signals and Lighting http://www.sanjoseca.gov/publicWorks/Details_Specs/

D. National Electrical Manufacturers Association (NEMA):

1. OS 1:Sheet-steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
2. 250:Enclosures for Electrical Equipment (1000 Volts Maximum).
3. TC 2: Electrical, Polyvinyl Chloride (PVC) Tubing and Conduit (EPC = 40 and EPC = 80).
4. TC 3: PVC Fittings for Use with Rigid PVC Conduit and Tubing.
5. RN 1: PVC Externally Coated Rigid Galvanized Steel Conduit and Electrical Metal Tubing.

E. National Electrical Code (NEC).

F. State of California Public Utilities Commission (Cal. PUC) G.O. 128: Construction of Underground Electrical Supply and Communications Systems, Rules For.

G. County of Santa Clara Standard Specifications, May 2000 http://www.sccgov.org/rda/attachments/(004_standard_specifications_may_2000_ss.pdf and amendments to Santa Clara Specifications (issued 1/07/2011) http://www.sccgov.org/sites/rda/About%20the%20Roads%20and%20Airports%20Department/Documents/(005_standard_specifications_amendments_ss.pdf

H. American National Standards Institute

1. (ANSI) C80.1: Zinc-Coated Galvanized Rigid Steel Conduit, Zinc Coated, Specification for.
2. (ANSI) C80.3: Electrical Metallic Tubing, Zinc coated, Specification for.

1.03 SYSTEM DESCRIPTION

A. Provide underground pull boxes for PG&E services, street lighting system, transit center lighting system, station lighting, substation lighting, Tail track lighting, Fiber Optic System, Photo Voltaic System and irrigation control feeders.

B. Underground pull boxes to be a part of a complete wiring system for all of the street lighting systems, station lighting, Fiber optic system and irrigation control feeders.

1.04 SUBMITTALS

A. Refer to Section 26 05 00, 1.06, Submittals.

B. Submit a list of all equipment and materials, and product data sheets of all materials intended for use to the Engineer for approval prior to start of work.

C. Quality/Assurance/Control Submittals

1. Test Reports: Provide test reports demonstrating load requirements are met.
2. Plot of drill alignment for conduit installed by directional drilling.

D. Prepare a site specific Directional Drilling Work Plan and Schedule and submit to the Engineer for approval as indicated in SC-6.21, Technical Submittal List. The schedule shall include all major tasks including examination of the areas. Prior to starting work review site conditions and confirm scope of work with owner's representative. Notify the Engineer immediately of any discrepancies from the plans or Drawings. Identify all utilities in the area and to include their locations on the work plan to be submitted to the Engineer and to include the following:

1. Conduit delivery
2. Rig mobilization and setup
3. Target dates for blockage and/or crossing of public/private roadways and anticipated duration of time for each occurrence
4. Conduit installation
5. Conduit testing
6. Restoration and demobilization
7. Target date for exit from project site
8. Disposal of waste

1.05 MEASUREMENT AND PAYMENT

A. Full compensation for work under this section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

B. The contract price paid for communication conduit shall be considered as included in the lump sum payment for "Story Station Communication Conduit" and "Eastridge Station Communication Conduit" and shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals needed for the furnishing and installing of the communication conduit as specified herein, as shown on the plans, and as directed by VTA. This lump sum contract price does not include trenching and backfilling as it is assumed that most of the conduit will be installed in a shared trench.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Oldcastle Precast or approved equal

1. Christy N9 Electrical Box 10-1/4" x 16-3/4" by Oldcastle Precast or approved equal
2. Christy FL09T Fiberlyte lid by Oldcastle Precast or approved equal
3. Christy N30 Electrical Box 13-1/4" x 24-1/4" by Oldcastle Precast or approved equal
4. Christy FL30T Fiberlyte lid by Oldcastle Precast or approved equal
5. Christy N36 Electrical Box 17-1/8" x 30-1/4" by Oldcastle Precast or approved equal

6. Christy FL36T Fiberlyte lid by Oldcastle Precast or approved equal

B. Quazite or approved equal

C. Galvanized Rigid Steel Conduit by Allied Tube & Conduit or approved equal

D. Insulated Grounding Bushings by Emerson or approved equal

E. Rigid/Intermediate Grade Conduit Fittings by Crouse-Hinds or approved equal

F. Rigid Non-Metallic Conduit Plus 40 by Carlon or approved equal

G. Schedule40 Conduit – Bell End by Cantex or approved equal

H. Carlon Bore-Gard™ Schedule 40 PVC conduit or approved equal

I. Rigid Non-Metallic Conduit Plus 80 by Carlon or approved equal

J. Electric Metallic Tubing (EMT) by Allied Tube & Conduit or approved equal

K. Liquidtight Flexible Metal Conduit by Southwire Company or approved equal

2.02 MATERIALS

A. Materials shall conform to the respective specifications and standards and to the Technical Specifications herein.

B. Pull boxes shall be No. 3.5 unless otherwise indicated on the Drawings or herein specified.

C. Pull boxes for VTA Systems: Non-traffic pull boxes for VTA systems shall be per Caltrans standard plan ES-8A except cover shall be the concrete type and marked as applicable, with the following:

1. “VTA-P” (For Power)
2. “VTA-C” (For Communication)
3. “VTA-I” (For Irrigation)

D. Material requirements for PG&E box shall meet PG&E requirements.

E. Pull boxes for City of San Jose Systems: Pull boxes for City of San Jose Systems shall conform to the City of San Jose Standard Details E-02 through E-07 except covers shall be the fiberlyte type fastened with stainless steel pentahead bolts.

F. Pull boxes for County of Santa Clara Systems: Non-Traffic pull boxes for the County of Santa Clara systems shall conform to the County of Santa Clara Standard Specifications except that the covers shall be fastened with the standard Caltrans stainless steel pentahead bolts and covers for Fiber Optic System shall be marked “COUNTY TEO” followed by “Fiber Optic”.

G. Junction Boxes: Junction boxes shall be waterproof, dustproof, and cast steel boxes. Use Crouse-Hinds WCB040404 or equal.

H. Conduit and conduit fittings shall be UL listed and conform to the following requirements:

1. Unless otherwise indicated on Drawings or in the Specifications, underground conduits and conduit fittings shall be nonmetallic Schedule 40 PVC;
2. Fittings: Bushings for nonmetallic conduit shall be nonmetallic.

I. Conduit shall be able to withstand 95% soil compaction without collapsing.

J. Where PVC conduit with a diameter greater than 3 inches is used for directional drilling operations, the PVC conduit must utilize a watertight, locking joint as found on Carlon Bore-Gard™ connections with locking rings and gaskets or similar conduit to prevent the conduit from separating as the conduit is pulled through the drilled path.

K. Conduit to be installed on the surface of structures or other exposed locations shall be rigid steel. Exposed conduit installed on a structure shall be painted the same color as the structure.

L. Conduit used across construction joints, hinges and other structural gaps shall be flexible to match the type of conduit continuing on either side of the flexible connection.

M. Grounding bushings shall be locking type and be provided with a feed through compression lug for installing a bonding jumper to the metal enclosures.

N. Wireways shall be galvanized metal with removable front panel for ease of pulling cable. Size shall be adequate for conductors included within.

O. Conduits for fiber installation shall include a flexible innerduct.

1. The Contractor shall furnish and install a flexible polyester/nylon textile innerduct, MaxCell by TVC Communications or approved equal, as shown on the plans and installed according to the manufacturer's recommendations. Rigid or semi-rigid innerduct are not allowed.

2. The polyester/nylon textile innerduct shall contain three cells and each cell shall accommodate a single cable with an outside diameter no larger than 0.85 inches. The polyester/nylon textile innerduct shall be sized to fit into the new conduit.

3. The polyester/nylon textile innerduct shall contain a 1,250lb polyester flat woven pull tape. The pull tape shall be constructed of synthetic fiber, and printed with accurate sequential footage marks.

4. A solid copper, polyvinyl color coated conductor (18AWG minimum) for tracing, rated for a minimum of 6 amps and 600 volts, shall be placed in the sidewall edge fold of the textile innerduct.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Special Techniques

1. Underground pull box installation shall conform to Cal. PUC. G.O. 128 and the National Electrical Code and shall be as specified herein and as indicated on the Drawings.
2. Pull boxes shall be grouted at the bottom per applicable Standard Details.
3. Install pull boxes with a 6 by 6 inch minimum PCC support ring around the pull box wherever pull boxes are installed in dirt or landscaped areas, except as shown in the City of San Jose Standard Details, unless noted otherwise.
4. Install pull boxes flush with the surrounding grade. Bolts on the lid shall be recessed to avoid presenting a tripping hazard.
5. Electrical normal power, emergency power, communication and telephone conduits and circuitry shall be independent from each other.
6. Conduit shall be run as directly as practical and be routed to avoid interference with underground piping, foundations, etc.
7. The Contractor shall install conduit by trenching, rock-wheeling, or directional drilling; except where crossing traffic lanes. Conduit crossing traffic lanes shall be installed by directional drilling.
8. Install end bells on all conduit ends unless noted otherwise.
9. Conduit bends shall be factory bent and shall have a radius not less than eight times the inside diameter of the conduit. In any one conduit run the total angle of bends shall not exceed 270 degrees.

10. Install expansion joints to match structural expansion joints, but in no case greater than 60 ft apart. Do not install on street lighting circuits.
11. During construction, protect partially completed conduits from the entrance of debris such as mud, sand, and dirt by means of suitable conduit plugs.
12. Encase underground conduit in at least 4 inches of sand. Conduit shall be run as directly as practical and be routed to avoid interference with underground piping, foundations, etc. Conduits shall be installed at least 2 feet below grade.
13. Stub-ups at locations of devices shall be temporarily capped, as approved by the Engineer, until installation of devices.
14. All spare conduits shall remain sealed with a conduit plug and pull rope.
15. Conduit on the platform shall be embedded in concrete and all stub-ups shall be 6 inches above finished surface unless otherwise shown on the Plans.
16. Conduit and junction boxes installed in the Pedestrian Overcrossing (POC) shall be installed by the structural manufacturer according to Plans.
17. Directional Drilling:
    a. Conduit shall be placed by the directional drilling method shall utilize a surface launch drill to install the conduit. Directional guidance shall be by means of a tracking system consisting of a radio beacon mounted in the bore head and a hand held locator, allowing tracking of the bore and changes of the drill path due to the presence of obstacles such as existing utilities. Bentonite or approved equal shall be placed inside the hole to fill all voids around the conduit(s).
    b. All new conduits to be directional drilled shall be placed at a depth with a cover between 24" and 60” in street areas, driveways, and areas subject to vehicular traffic and at a depth with a cover between 18” and 48” in sidewalk and behind curb. New conduits shall be placed at a minimum depth of 36” in unimproved areas, including areas without curb, gutter or sidewalk. Contractor shall mark the progress and depth of the bore at 20' intervals by applying a paint dot to the ground in the same color scheme as used for Underground Service Alert. Deviations from the approved drawings shall be corrected immediately to get the bore back to the approved alignment and depth.
    c. If the Contractor encounters difficulty in completing a directional drill due to unforeseen underground circumstances, the Engineer may approve the conduit to be installed by open trench or rock-wheel method as a substitute at that location.
    d. Conduit to be installed by directional boring shall have a minimum cure time of 2 hours prior to fastening to boring equipment and shall be supported with a cable inside the conduit connected to a support block at the end opposite the drill machine.
    e. Drill a pilot hole with fluid assisted mechanical cutting head along a predetermined path to a specified target location. The exact method and techniques for completing directionally drilling shall be determined by the Contractor, subject to the requirements of these Specifications and approval by the Engineer. Drilling fluid can be a mixture of water and Bentonite, polymers, or other approved additives. No fluid shall be discharged into the streets, gutters, or sewers. Fluid pressure and flow rate shall be minimized during the drilling operation to prevent fracturing the sub-grade material around and above the pilot hole. Uncontrolled jetting is prohibited. Any fluid discharged onto streets, sidewalks or customer property, shall be properly disposed of including cleaning of the affected area. Excess drilling fluid must be removed from the surface of relief holes prior to paving. After the conduit has been pulled into the reamed pilot hole, the Conduit shall be pulled so that 10 feet of conduit is exposed on the end of the bore. The conduit shall be cleaned so that the exterior can be examined. The Contractor shall at all times provide and maintain instrumentation which will accurately locate the pilot hole and measure drilling fluid

flow discharge rate and pressure. The Engineer shall have access to these instruments and their readings at all times.

f. Enlarge pilot hole with cutters or reamers to size 4 inch hole for 2 inch conduit, 6 inch hole for 3 inch conduit, and 8 inch hole for 4 inch conduit) and pull in specified size pipe while injecting fluid mixtures to hold reamed hole open and lubricate the utility line being pulled. A commercially available weak link approved by the Engineer shall be used between the puller and the pipe. The maximum pull force shall be 6200N for 2 inch, 11.5 kN for 3 inch, and 18.7kN for 4 inch.

g. Each bore shall be completed, including pipe pulling, on the same day as that bore is started.

h. Where abandoned concrete, obstructions, existing utilities, and/or abandoned utilities are encountered during directional drilling which prevent the installation of the conduit, the conduit alignment may be revised and/or additional pull boxes may be installed as required to avoid the obstruction. Such revisions to the conduit alignment and pull box layout will be at the Contractor’s expense and will require the prior written approval of the Engineer.

i. Where soil conditions, trees, rocks, deep asphalt, deep aggregate base, and/or other materials are encountered during directional drilling which require additional work, the Contractor shall perform the additional work at no cost to the VTA.

j. Plot the actual horizontal and vertical alignment of the pilot drill at intervals not exceeding 50 feet. This “as-built” plan and profile shall be updated as the pilot drill is advanced. Employ experienced personnel to operate the directional drilling equipment and, in particular, the position monitoring and steering equipment. No information pertaining to the position or inclination of the pilot drill shall be withheld from the Engineer. At the completion of the pilot hole the Contractor shall provide the Engineer with the plotted horizontal and vertical alignment locations of the pilot hole.

18. Open Trenching and Rock-wheeling:

a. In areas without pavement or sidewalk, conduit shall be installed with a minimum cover of 3 feet. In roadway areas, driveways, and areas subject to vehicular traffic conduit shall be installed with a minimum depth of 2 feet. In areas behind curb, park strips, landscaping, sidewalks, and improved areas not subject to vehicular traffic, conduit shall be installed with a minimum depth of 1.5 feet.

b. In roadway areas, cover conduit with 4 inch sand bedding and backfill trench with Portland cement concrete to grade. Excavation/installation of conduit and concrete backfill shall be completed within the same working day. Remove full pavement section and replace with Portland cement concrete in the area between trenches that are less than 6 inch apart. Remove full pavement section and replace with Portland cement concrete in the area between trenches lip of gutter that are less than 6 inch apart. Within 5 days, grind the trenched area and 6 inch on both sides of the trench 1 inch minimum deep. Extend the grind area to lip of gutter if within 24 inch of the lip of gutter. Extend the grind area over, and 6 inch beyond, new or existing trenches within 24 inch of new trenches. Apply tack coat and install type B medium asphalt concrete cap to grade in grind areas.

c. All longitudinal trenches shall be located as indicated on the Drawings. All traffic striping and pavement markings shall be restored and/or repainted if removed during excavation or trenching process. Replacement traffic striping and pavement markings shall match original material. Temporary striping or reflectors shall be used during construction.

d. The Contractor’s rock-wheeling equipment shall have a mounted water tank, an attached conveyor belt and shall be in good working condition at all times. Water supply to the rock-wheel and for cleaning the street, when necessary, shall be maintained and immediately available. The beginning and end of the trenches shall be saw-cut vertically.

e. The outline of all areas of pavement to be removed shall be cut with an abrasive type saw or with a rock cutting excavator specifically designed for this purpose. Cuts shall be neat and true with no shatter outside the removal area. The rock-cutting excavator shall be shielded to prevent loose material from being thrown away from the machine.

B. Interface with Other Work

1. Excavation, backfilling, and surface reconstruction shall conform to the requirements of Section 31 00 00, Earthwork
2. Contractor shall clean and restore grout in all pull boxes (new and existing) where new conduit or wire is installed. All pull box lids damaged by Contractor operations shall be replaced at his expense.
3. Where an existing pull box is to be replaced with a new, larger pull box, Contractor shall also be responsible to modify conduits entering the new pull box to conform to standards for new installations as shown on Standard Specifications and Standard Details and these technical specifications.
4. PVC conduit bell ends shall be installed on all conduit entering pull boxes except metallic conduit, which shall have threaded ground bushings.
5. All utility crossings potentially in the proposed conduit alignment shall be potholed and exposed to verify depth prior to commencing with the drilling operation. Potholes shall be open when the drill and conduit have been installed beyond the exposed utility to verify that no damage has occurred.

C. Sequence of Operation

1. The Contractor shall stake or mark the location of each new pull box location. The exact location shall be determined after careful consideration has been given to the location of other utilities, grading and paving. Pull boxes shall not be installed until after the location is reviewed by the Engineer.

D. Site Tolerances

1. Pull boxes shall be located behind the curb at the approximate locations shown on the Drawings as dimensioned in the Standard Details, unless noted otherwise.
2. No deviation of more than 30” in horizontal alignment from the location shown on the Drawings will be accepted unless revised alignment has been submitted and reviewed by the Engineer.

E. Testing and Cleaning

1. As each section of conduit between boxes is completed, a testing mandrel with a diameter 0.25 inch less than the size of the conduit, shall be drawn through each conduit, after which a brush having the diameter of the duct, and having stiff bristles shall be drawn through until the conduit is clear of all particles of earth, sand, or gravel. Compressed air shall be used to blow out the remaining residue.
2. Conduit plugs shall then be immediately installed.
3. A plastic pull rope having 3 feet of spare at each end shall be installed in each conduit.
4. Contractor shall notify the Engineer at least 24 hours prior to mandrel testing of conduits. Testing shall be recorded on a test report. Contractor shall submit a sample form, to be approved by the Engineer prior to start of testing. Test reports shall be prepared on a pull box to pull box basis, and shall include as a minimum, the contract number, date, test engineer, identification of each conduit number, origin, destination, length and size of conduit, and pass/fail mandrel status. Test reports shall be signed by Contractor at the time of the test, and submitted to the Engineer.

END OF SECTION 26 05 33

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SECTION 26 05 34

SYSTEMWIDE ELECTRICAL CONDUITS FOR SYSTEMS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for providing complete conduit and conduit systems for the combined systems duct.

1.02 RELATED SECTIONS

A. Record Document procedures are specified in Section 01 78 39, Project Record Documents.

B. General systemwide electrical requirements are specified in Section 26 05 00, Common Work Results for Electrical Systems.

C. Underground duct banks are specified in Section 26 05 43, Systemwide Underground Ductbanks.

D. System manholes and handholes are specified in Section 26 05 44, Systemwide Electrical Manholes and Pullboxes.

E. System cable trough is specified in Section 26 05 45, Systemwide Electrical Cable Trough.

F. Dewatering is specified in Section 31 23 19, Dewatering.

1.03 REFERENCED STANDARDS

A. American National Standards Institute (ANSI)

1. ANSI C80.1 Specifications for Rigid Steel Conduit, Zinc Coated

B. American Society for Testing and Materials (ASTM):

1. ASTM A29 Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought

C. National Electrical Manufacturers Association (NEMA)

1. NEMA RN 1 PVC Externally-Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
2. NEMA TC2 Electrical Plastic Tubing (EPT) and Conduit (EPC 40 and EPC 80)
3. NEMA TC3 PVC Fittings for Use with Rigid PVC Conduit and Tubing

D. National Fire Protection Association (NFPA)

1. NFPA 70 National Electrical Code (NEC)

1.04 SUBMITTALS

A. General: Refer to Special Conditions for submittal requirements and procedures.

B. Submit product data for the following:

1. Product data on conduits
2. Product data on fittings
3. Product data on metallic joint compounds, caulking and sealing compounds
4. Product data on pull cords
5. Product data on conduit tags and labels
6. Product data on conduit mandrels and brushes
7. Product data on warning tape
8. Product data on polyvinyl chloride (PVC) conduit joint cleaning solvent and cement
9. Product data on PVC/GRSC (galvanized rigid steel conduit) coating patching compound
10. Product data on detailed installation instructions for special innerduct

C. Record Documents: Provide copies of all approved submittals, specified herein, for record purposes in accordance with the requirements of Section 01 78 39, Project Record Documents.

1.05 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.

C. Quality assurance planning, implementation and reporting shall be in conformance with the Special Conditions, except as modified herein.

1.06 MEASUREMENT AND PAYMENT

A. Measurement:

1. 5" PVC Schedule 40 Conduit shall be measured by the Linear Foot.
2. 5" PVC Coated RGS Conduit shall be measured by the Linear Foot.
3. 4" PVC Schedule 40 Conduit shall be measured by the Linear Foot.
4. 4" PVC Coated RGS Conduit shall be measured by the Linear Foot.
5. 3" PVC Schedule 40 Conduit shall be measured by the Linear Foot.
6. 3" PVC Schedule 80 Conduit shall be measured by the Linear Foot.
7. 2" PVC Schedule 40 Conduit shall be measured by the Linear Foot.
8. 2" PVC Schedule 80 Conduit shall be measured by the Linear Foot.
9. 1.5” PVC Coated RGS Conduit shall be measured by the Linear Foot.
10. 1" PVC Schedule 80 Conduit shall be measured by the Linear Foot.

B. Payment:

1. The contract price paid per Linear Foot for 5" PVC Schedule 40 Conduit shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in 5” PVC schedule 40 conduit complete in place, as shown on

the drawings, as specified in these Technical Specifications, and as directed by the VTA.

2. The contract price paid per Linear Foot for 5" PVC Coated RGS Conduit shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in 5" PVC coated RGS conduit complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
3. The contract price paid per Linear Foot for 4" PVC Schedule 40 Conduit shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in 4" PVC schedule 40 conduit complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
4. The contract price paid per Linear Foot for 4" PVC Coated RGS Conduit shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in 4" PVC coated RGS conduit complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
5. The contract price paid per Linear Foot for 3" PVC Schedule 40 Conduit shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in 3" PVC schedule 40 conduit complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
6. The contract price paid per Linear Foot for 3" PVC Schedule 80 Conduit shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in 3" PVC schedule 80 conduit complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
7. The contract price paid per Linear Foot for 2" PVC Schedule 40 Conduit shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in 2" PVC schedule 40 conduit complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
8. The contract price paid per Linear Foot for 2" PVC Schedule 80 Conduit shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in 2" PVC schedule 80 conduit complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
9. The contract price paid per Linear Foot for 1.5" PVC Coated RGS Conduit shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in 1.5" PVC Coated RGS Conduit complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
10. The contract price paid per Linear Foot for 1" PVC Schedule 80 Conduit shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in 1" PVC schedule 80 conduit complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 CONDUIT REQUIREMENTS

A. Conduits shall be Schedule 40 Polyvinyl Chloride (PVC), unless one of the following cases is met:

1. Where a duct includes a 90-degree bend and is subject to cable pulling by mechanical means.
2. Where a duct includes a 90-degree or 45-degree bends for stub-ups.

B. If one of the following cases is met, conduit material shall be the following:

1. Traction Power Positive: PVC Coated Rigid Galvanized Steel (PVC/GRSC OR PGRSC)
2. Traction Power Negative: PVC Coated Rigid Galvanized Steel (PVC/GRSC OR PGRSC)
3. Signal Equipment: Schedule 80 PVC
4. Communication Equipment: Schedule 80 PVC

C. Conduits shall meet the following criteria:

Duct Size (inches)	Diameter (inches)	Working Load (pounds)
2.0	1.88	2,330
2.5	2.19	2,330
3.0	2.81	2,330
3.5	3.25	4,800
4.0	3.75	4,800
5.0	4.69	4,800

2.02 PVC CONDUIT

A. Conduit shall comply with NEMA TC 2, rigid polyvinyl chloride, Schedule 40 or Schedule 80. Conduit shall be sunlight resistant and suitable for 90 degrees Celsius conductors and exposed locations.

2.03 PVC COATED GALVANIZED RIGID STEEL CONDUIT

A. Conduit shall comply with ANSI C80.1 and NEMA RN 1, and shall be hot-dipped galvanized inside and out. Threaded ends shall be galvanized using a zinc metalizing process which sprays or blasts molten or semi-molten zinc on the threaded area.

B. The galvanized surface shall be coated with an epoxy-acrylic primer to insure a bond between steel and plastic.

C. The plastic coating on the exterior of conduit shall be applied by the plastisol method, to 40 mils minimum thickness.

2.04 PVC CONDUIT FITTINGS

A. Fittings for PVC conduit shall comply with NEMA TC 3. PVC conduit fittings shall be of the same manufacturer and type as the conduit.

2.05 PGRSC CONDUIT FITTINGS

A. Fittings for PGRSC conduit shall be the same manufacturer and specifications as the PVC/GRSC conduit.

2.06 CONDUIT MANDRELS AND BRUSHES

A. Conduit brushes shall use round wire bristles for maximum cleaning of sand, grit, and obstructions from the conduit. They shall have a pulling eye on one end, and a smaller twisted eye on the other end, which shall allow for bi-directional pulling. Conduit brushes shall be sized as shown in Table A.

TABLE A
CONDUIT BRUSH SIZES

Duct Size (inches)	Diameter (inches)	Working Load (pounds)
2.0	1.87	200
2.5	2.38	200
3.0	2.87	200
3.5	3.38	200
4.0	3.87	200
5.0	4.87	200
6.0	5.87	200

B. Conduit mandrels shall be flexible, and manufactured for cleaning out mud, dirt and light obstacles from ducts before the installation of cable. Mandrels shall be suitable for pulling around tight bends, and use a tapered profile which allows pulling in either direction. Pulling eyes shall be furnished on each end. The mandrel shall be fabricated from polyurethane, or an approved equal material, and shall not damage conduit inner walls. Conduit mandrels shall be sized per Table B or as Approved by the Engineer.

TABLE B
CONDUIT MANDREL SIZES

Duct Size (inches)	Diameter (inches)	Working Load (pounds)
2.0	1.88	2,330
2.5	2.19	2,330
3.0	2.81	2,330
3.5	3.25	4,800
4.0	3.75	4,800
5.0	4.69	4,800
6.0	5.81	4,800

C. Conduit brushes and mandrels shall be manufactured for the purpose by a company regularly engaged in the production of electrical equipment. Mandrels shall not be fabricated by the Contractor in the shop or field.

2.08 DIRECTIONAL BORING

A. Directional boring equipment shall consist of a directional boring rig of sufficient capacity to perform the bore and pull back the pipe, a boring fluid mixing and delivery system of adequate capacity to successfully complete the crossing, a guidance system to accurately guide boring operations and trained and competent personnel to operate the system.

B. The directional boring machine shall consist of a hydraulically powered system to rate, push and pull hollow drill pipe into the ground at a variable angle while delivering a pressurized fluid mixture to a guidable drill head. The machine shall be anchored to the ground to withstand the pulling, pushing and rotating pressure required to complete the crossing. Hydraulic systems shall be free of leaks. Rig shall have a system to monitor and record maximum pull-back pressure during pull-back operations. The rig shall be grounded during boring and pull-back operations.

C. The bore head shall be steerable by changing its rotation and shall provide the necessary cutting surfaces and boring fluid jets.

D. Mud motors, if required, shall be of adequate power to turn the required boring tools.

E. Pipe shall be constructed of seamless tubing conforming to ASTM A29, grade D or better, with threaded box and pins.

F. System shall be of a proven type and shall be setup and operated by personnel trained and experienced with this system. The operator shall be aware of any magnetic anomalies and shall consider such influences in the operation of the guidance system if using a magnetic system

G. Boring Fluid (Mud) System

1. A self-contained, closed, boring fluid mixing system shall of sufficient size to mix and deliver boring fluid composed of bentonite clay, potable water and appropriate additives. Mixing system shall be able to molecularly shear individual bentonite particles from the dry powder to avoid clumping and ensure thorough mixing. The boring fluid reservoir tank shall be large enough to accommodate the necessary fluid amount. Mixing system shall continually agitate the boring fluid during operation.
2. Drilling fluid shall be composed of clean water and an appropriate additive. Water shall be from a clean source with a pH of 8.5-10. Water of a lower pH or with excessive calcium shall be treated with the appropriate amount of sodium carbonate or equal. The water and additives shall be mixed thoroughly and be absent of any clumps or clods. No hazardous additives may be used. Boring fluid shall be maintained at a viscosity sufficient to suspend cuttings and main the integrity of bore wall.

PART 3 – EXECUTION

3.01 GENERAL INSTALLATION REQUIREMENTS

A. Conform with additional installation requirements of Section 26 05 00, Common Work Results for Electrical Systems.

B. All ducts shall be installed with a 1/4-inch nylon pull-cord installed and secured at each end.

C. All ductbanks shall have a trace wire installed along its entire length initiating from a manhole and terminating at the ductbank end. Trace wires installed within a manhole shall be terminated within an appropriately rated enclosure on a terminal strip and identified with its corresponding ductbank number. Tie-in trace wires to the existing conduits.

D. Install conduits with innerducts as specified in the plans.

E. Install conduits with not more than 270 degrees of bend, total, in each conduit run between boxes, manholes, handholes and conduit terminations.

F. Unless otherwise noted, minimum conduit size shall be 2 inch for underground conduits.

G. Cut conduit ends square, ream and extend maximum distance into all couplings and connectors. Tighten all fittings securely. Filed cut threads and reamed ends in metal conduit shall be protected from corrosion immediately after cutting, reaming and cleaning by application of a zinc rich coating.

H. Metallic conduit joints shall be electrically continuous by use of conductive joint compounds.

I. Install manufactured end caps or plugs on all conduit ends immediately after installation to prevent the entrance of liquids or foreign materials.

J. Minimum bend radius for conduits within structures shall be in accordance with Table 2, Chapter 9, of the NEC and the requirements of this Section:

1. 5-inch duct: 48” radius
2. 4-inch duct: 36” radius
3. 3-inch duct: 24” radius
4. Other Duct sizes: 24” radius

K. Route conduits to avoid structural obstructions and to minimize crossovers. Should core drilling or installation of sleeves not shown on the Contract Drawings be desired by the Contractor, such proposed penetrations shall be submitted to the Engineer prior to any core drilling or sleeving.

L. Install expansion fittings with grounding jumpers where conduits cross expansion joints, construction joints, sawn joints, and where shown.

M. All connections shall be watertight.

N. Install PVC conduit in accordance with manufacturer's instructions. Cut the conduit ends square, and apply an approved solvent to clean the joint. Apply approved cement and allow to set 24 hours before mandrelling, brushing and installing conductors.

O. Install all ground bushings and incidentals.

P. All PVC conduits entering manholes, pullboxes and handholes shall be terminated with bell-end fittings or Term-a-duct in conformance with Section 26 05 44, Systemwide Electrical Manholes and Pullboxes.

Q. PVC/GRSC and fittings require special installation methods, and shall be installed in strict accordance with the manufacturer's instructions. Provide PVC boot to cover all exposed threads. Touch-up minor slice, nick, or abrasion damage to PVC coating with patching compound approved by the conduit manufacturer. Slices more than 10 mils in depth, and nicks and abrasions more than 10 mils in depth or 1/4-inch in diameter are considered major damage. Patching compound shall not be used to correct major damage. Conduits and fittings with major damage shall be replaced. The Engineer shall be the sole judge of whether coating damage is minor or major.

3.02 UNDERGROUND CONDUITS

A. Conform with requirements of this Section and requirements of 26 05 43, Systemwide Underground Ductbanks.

B. Connect conduits to systemwide cable trough in accordance with Section 26 05 45, Systemwide Electrical Cable Trough.

C. Slope conduits entering manholes and handholds to drain towards them.

D. Install conduits a minimum of 3 feet below final grade unless otherwise indicated.

E. Dewater all excavations and conduits in conformance with the requirements of Section 31 23 19, Dewatering.

3.03 SLEEVES

A. All sleeves shall be PVC/GRSC or Schedule 40 PVC as noted in Contract Drawings.

B. Install, in advance of pouring concrete, all sleeves where shown. Sleeves shall terminate flush with the surface of the concrete with a coupling. Install at such depth that the exposed conduit is vertical and no curved section of the elbow is visible.

3.04 SEALING OF CONDUIT PENETRATIONS

A. Seal around all penetrations in exterior wall surfaces above grade with silicone caulking. For penetrations in concrete construction above grade, cast conduit penetrations into wall.

B. Exterior surfaces below grade shall have conduits cast into wall or floor. If core drilling or installing sleeves as conduit penetrations, install sealing fittings.

C. Where conduits are installed in other openings or blockouts, hard pack around penetration using mortar made from an equal mixture of sand and cement.

3.05 CONDUIT MANDRELLING AND CLEANING

A. A log shall be kept for all conduits mandrelled. The mandrel log shall contain the following information in tabular format for each conduit mandrelled:

1. Conduit designation
2. Conduit endpoints
3. Conduit size
4. Date mandrelled
5. Pass/fail for specified mandrel

B. After final assembly is in place, all conduit 2 inches and larger shall be thoroughly mandrelled and cleaned prior to installing wires or pull cords. Each conduit shall be mandrelled by pulling a mandrel sized in accordance with these Specifications through the conduits, followed by a steel bristle brush to clean the conduit.

C. After final assembly is in place, all conduits smaller than 2 inches shall be thoroughly cleaned and mandrelled by one of the following methods:

1. Pulling through the conduits a mandrel and wire brush sized 1/4 inch maximum less than the inside diameter of the conduit for 1-1/2 inch and 1-1/4 inch conduits, and 1/8 inch maximum less than the inside diameter of the conduit for 1-inch and smaller conduits.
2. Pulling through the conduits a cloth rag or conductor bundle sized 1/4 inch maximum less than the inside diameter of the conduit for 1-1/2 inch and 1-1/4 inch conduits, and 1/8 inch maximum less than the inside diameter of the conduit for 1-inch and smaller conduits.

D. If requested by the Engineer, mandrelling and cleaning shall be done in the presence of the Engineer. Notify the Engineer 7 days in advance of mandrelling.

E. Where conduits are stubbed and capped, the pull cord shall extend through a drilled hole in the cap.

F. Conduits which cannot meet the requirements for mandrelling shall be deemed defective, and shall be replaced as directed by the Engineer.

3.06 UNDERGROUND CONDUIT LABELING

A. Identify each conduit in vaults with painted identification number on the vault wall.

3.07 INSTALLATION AND OPERATION OF DIRECTIONAL BORING

A. All personnel shall be fully trained in their respective duties as part of the directional boring crew and in safety. Training shall be provided specific to the project if any potential hazards may be encountered which has not already been included in personnel’s training.

B. Prior to any alterations to the work-site, the Contractor shall photograph the work area, including entry and exit points. Work site as indicated on the Contract Drawings, within right-of-way, shall be graded or filled to provide a level working area. No alterations beyond what is required for operations are to be made. The Contractor shall confine all activities to designated work areas.

C. Entire drill path shall be accurately surveyed with entry and exit stakes placed in the appropriate locations within the areas indicated on the Contract Drawings. If the Contractor is using a magnetic guidance system, drill path will be surveyed for any surface geo-magnetic variations or anomalies.

D. The Contractor shall place silt fence between all boring operations and any drainage, wetland, waterway or other area designated for such protection by the Contract Documents, State, Federal and Local regulations. Additional environmental protection necessary to contain any hydraulic or boring fluid spills shall be put in place, including berms, liners, turbidity curtains and other measures. The Contractor shall adhere to all applicable environmental regulations. Fuel or oil may not be stored in bulk containers within 200 feet of any water-body or wetland.

E. The Contactor shall notify all companies with underground utilities in the work area to locate existing utilities. Once the utilities have been located, the Contractor shall physically identify the exact location of the utilities by vacuum or hand excavation, when possible, in order to determine the actual location and path of any underground utilities which might be within 20 feet of the bore path. The Contractor shall not commence boring operations until the location of all underground utilities within the work area have been verified.

F. Pipe shall be connected together in one length prior to pull-back operations, if space permits. Steel pipe welds will be x-rayed prior to being placed in bore hole. Pipe will be placed on pipe rollers before pulling into bore hole with rollers spaced close enough to prevent excessive sagging of pipe.

G. Upon successful completion of pilot hole, the Contractor will ream bore hole to a minimum of 25 percent greater than outside diameter of pipe using the appropriate tools. The Contractor will not attempt to ream at one time more than the boring equipment and mud system are designed to safely handle.

H. After reaming bore hole to the required diameter, the Contractor will pull the pipe through the bore hole. In front of the pipe will be a swivel. Once pull-back operations have commenced, operations must continue without interruption until pipe is completely pulled into bore hole. During pull-back operations the Contractor will not apply more than the maximum safe pipe pull pressure at any time. In the event that pipe becomes stuck, the Contractor will cease pulling operations to allow any potential hydro-lock to subside and will commence pulling operations.

I. Following boring operations, the Contractor will de-mobilize equipment and restore the work-site to original condition. All excavations will be backfilled and compacted to 95 percent of original density. Landscaping will be restored to original or as otherwise indicated on the Drawings.

END OF SECTION 26 05 34

SECTION 26 05 43

SYSTEMWIDE UNDERGROUND DUCTBANKS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for providing ductbanks as shown on the Contract Drawings and as specified herein. Ductbanks shall be defined as one or more conduits and fitting combinations embedded in concrete.

1.02 RELATED SECTIONS

A. Record Document procedures are specified in Section 01 78 39, Project Record Documents.

B. General systemwide requirements are specified in Section 26 05 00, Common Work Results for Electrical Systems, and Section 26 05 34, Systemwide Electrical Conduits for Systems.

C. System manholes and handholes are specified in Section 26 05 44, Systemwide Electrical Manholes and Pullboxes.

D. Dewatering is specified in Section 31 23 19, Dewatering.

1.03 REFERENCED STANDARDS

A. American Society for Testing and Materials (ASTM):

1. ASTM A615 Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
2. ASTM C33 Standard Specification for Concrete Aggregates
3. ASTM C94 Standard Specification for Ready-Mixed Concrete
4. ASTM C150 Standard Specification for Portland Cement

B. Institute of Electrical and Electronic Engineers (IEEE)

1. IEEE C2 National Electrical Safety Code (NESC)

C. National Fire Protection Association (NFPA)

1. NFPA 70 National Electrical Code (NEC)

1.04 SUBMITTALS

A. General: Refer to Special Conditions for submittal requirements and procedures.

B. Submit product data for the following:

1. Concrete Mix Design
2. Reinforcing Steel
3. Duct Spacers

C. Record Documents: Provide copies of all approved submittals, specified herein, for record purposes in accordance with the requirements of Section 01 78 39, Project Record Documents.

1.05 QUALITY ASSURANCE

A. As-built drawings shall be provided in accordance with the requirements of Section 26 05 00, Common Work Results for Electrical Systems, except as modified herein.

B. As-built drawings shall show the location of all underground ductbanks and the number and size of conduits therein.

C. Comply with ANSI/IEEE C2.

D. Comply with NFPA 70.

1.06 MEASUREMENT AND PAYMENT

A. Measurement:

1. Concrete Duct Bank Encasement shall be measured by the Cubic Yard.
2. Reinforced Concrete Duct Bank Encasement shall be measured by the Cubic Yard.

B. Payment:

1. The contract price paid per Cubic Yard for Concrete Duct Bank Encasement shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing concrete duct bank encasement in place, including trenching, formwork and backfill, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
2. The contract price paid per Cubic Yard for Reinforced Concrete Duct Bank Encasement shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing reinforced concrete duct bank encasement in place, including trenching, reinforcing steel, concrete, formwork, and backfill as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 CONDUITS

A. Conduits shall conform to the requirements of Section 26 05 34, Systemwide Electrical Conduits for Systems.

B. Raceway spacers shall be plastic, lock together, and be sized to create clear spaces of 3 inches or greater between conduits

2.02 ENCASEMENT AND REINFORCEMENT

A. Ready-Mix concrete shall comply with ASTM C94 and the following requirements:

1. 28 Day Compressive strength of 3000 psi.
2. Slump between 2 inches and 4 inches
3. Red dye added at the rate of 3 pounds per sack of cement.

B. Concrete shall comply with ASTM C150, Type I.

C. Aggregate shall comply with ASTM C33, ¾" max aggregate.

D. Reinforcement shall comply with ASTM A615, Grade 40.

PART 3 – EXECUTION

3.01 GENERAL

A. Coordinate installation of underground ducts with other construction Work. Maintain any existing utilities in operation unless otherwise directed by the Engineer.

B. Concrete encasement shall be limited to the neat lines shown on the Contract Documents. The Contractor shall be responsible for coordinating placement of the concrete with other Work.

C. Protect and maintain all new or existing benchmarks or other reference points necessary for the completion of the Work.

3.02 TRENCH EXCAVATION AND BACKFILL

A. Provide a minimum cover of 36 inches over all underground ductbanks unless otherwise indicated.

B. When trench walls are stable, use the walls of the trench as forms for concrete encasement. The trench shall be made no wider than necessary to provide the nominal concrete encased ductbank.

C. Excavations shall be dewatered in accordance with Section 31 23 19, Dewatering. The excavation shall be cleaned prior to raceway and concrete placement.

D. Provide a compacted base under the ductbank.

3.03 CONCRETE ENCASEMENT

A. All duct banks shall be encased in concrete. Duct bank shall be reinforced concrete when crossing under roadways or tracks and within the Traction Power Substation sites. Reinforced concrete encasement shall extend 6 feet beyond edge of rail or roadway or as indicated on the contract documents.

3.04 RACEWAY PLACEMENT

A. Ducts shall be arranged as shown on the Contract Drawings.

B. Generally the ductbank is located below the end of the track ties at a minimum depth of 30 inches below bottom of tie. Lateral ductbank crossings below the track is permitted as long as the ductbank meets the minimum depth requirements. Where obstacles are encountered the ductbank shall gradually offset around them and must meet the concrete-encasement and conduit bending requirements.

C. Ductbanks for utility systems shall maintain a minimum 5 foot horizontal separation unless otherwise indicated on the Contract Drawings or Approved by the Engineer.

D. Slope all raceway for drainage to manholes or handholes.

E. Raceway spacers shall be placed at maximum 5-foot intervals. Bending radii indicated on the Contract Drawings and specified herein are to be considered minimum, unless noted otherwise.

F. Terminate all PVC conduit ductbank entering the manholes/pullboxes from the sidewall with approved bell ends glued to the ends of the PVC conduits or term-a-duct. Coordinate with additional requirements of Section 26 05 44, Systemwide Electrical Manholes and Pullboxes.

G. Secure ducts to prevent displacement during concrete encasement or earth backfilling. Make minor changes in location or cross-section as necessary to avoid obstructions or conflicts. Where raceway runs cannot be installed as shown because of conditions not discoverable prior to trenching, refer the condition to the Engineer for direction before further work is done.

H. When placing concrete around the raceways, adjust the delivery chute so the fall distance of the concrete into the trench is minimal. Concrete direct fall distance shall be 2 feet or less. Use a splash board to divert the flow of concrete away from the trench sides and avoid dislodging soil and stones.

I. All plastic raceways may expand or contract as concrete is placed and cured. Therefore, when placing concrete encasement, always encase from one end of the duct section toward the other end to allow the free end to move. Never encase from each end of the section toward the center.

J. Place concrete continuously between manholes, handholes and pullboxes. If the placement stops for more than 2 hours, 8 foot lengths of No. 4 reinforcement steel shall be placed longitudinally around the perimeter of the concrete envelope on 12 inch centers and with 2 inches minimum cover. Half of each 8-foot length shall be in each pour.

K. Where concrete encased ductbanks are terminated for future extension, stub out and cap all conduits at least 1 foot beyond the end of ductbank concrete. With top row closest to the end of concrete, stagger ends of horizontal rows of conduits for ease in making future ductbank extensions. Extend reinforcement steel at least 4 feet of each rebar embedded in ductbank concrete. Prior to backfilling, record location of end of ductbank as determined by surveying from an existing survey station which will remain until Contract completion. Submit to the Engineer prior to beginning any such surveying, a plan indicating how surveying will be carried out, including survey stations to be used to determine ductbank end locations. Provide to the Engineer copies of all survey data. Prior to completion of Contract, re-survey ductbank endpoints and provide a 4 inch by 4 inch by 6 foot treated wood post painted white to mark the ductbank termination location. Permanently label each such post with brass screws and a brass tag stamped with the ductbank number and coordinates per schedule, and the ductbank burial depth. Install the marker post 2 feet in the ground centered between tracks.

L. Mandrel raceways and provide seals in accordance with Section 26 05 34, Systemwide Electrical Conduits for Systems. Ductbank conduits shall be mandrelled after concrete encasement but before backfilling.

3.04 INSPECTION

A. Ductbanks shall be inspected by the Engineer before placing concrete encasement. Notify the Engineer before placing concrete. Clean trenches, dewater and adjust clearances as directed to obtain the minimum concrete dimensions shown on the Contract Drawings.

END OF SECTION 26 05 43

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SECTION 26 05 44

SYSTEMWIDE ELECTRICAL MANHOLES AND PULLBOXES

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for providing complete manholes, vaults and pullboxes.

1.02 RELATED SECTIONS

A. Section 01 78 39, Project Record Documents

B. Section 26 05 26, Grounding and Bonding for Electrical Systems

C. Section 31 00 00, Earthwork

D. Section 31 23 19, Dewatering

E. Section 34 21 01, Traction Power Basic Electrical Materials and Methods.

1.03 REFERENCED STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO)

1. AASHTO HS20 Bridge Design Criteria

B. American Iron and Steel Institute (AISI)

1. Type 316 Stainless Steel Specification

C. American Society for Testing and Materials (ASTM):

1. ASTM A615 Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
2. ASTM C857 Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures

D. Institute of Electrical and Electronic Engineers (IEEE)

1. IEEE C2 National Electrical Safety Code (NESC)

1.04 SUBMITTALS

A. General: Refer to Special Conditions for submittal requirements and procedures.

B. Submit product data for the following:

1. Pullbox shop drawing including cover and frame, cable supports and inserts, and any required extension sections.
2. Cable supports and racks
3. Cable insulators
4. Pulling iron
5. Concrete damp proofing compound

C. Record Documents: Provide copies of all approved submittals, specified herein, for record purposes in accordance with the requirements of Section 01 78 39, Project Record Documents.

1.05 MEASUREMENT AND PAYMENT

A. Measurement:

1. CSD Pullbox shall be measured by the unit count (each).
2. CSD Pullbox Racking shall be measured by the unit count (each).
3. CSD Pullbox (Aerial Guideway) shall be measured by the unit count (each).
4. Demolish CSD Run and Pullbox shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment:

1. The contract price paid per unit count (each) for CSD Pullbox shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in installing CSD pullboxes complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
2. The contract price paid per unit count (each) for CSD Pullbox Racking shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in installing CSD pullbox racking complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
3. The contract price paid per unit count (each) for CSD Pullbox (Aerial Guideway) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in installing CSD guideway pullboxes complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.
4. The lump sum payment for Demolish CSD Run and Pullbox shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in demolishing CSD runs and vaults or pullboxes complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 PRECAST CONCRETE PULLBOXES

A. Pullboxes shall be precast concrete with 28-day, 4,500 psi or greater compressive strength concrete and designed for minimum AASHTO H20-S16 loading. Minimum dimensions for manholes/pullboxes are shown on the Contract Drawings. Extension sections shall be used to increase vertical dimensions to those shown on the Contract Drawings.

B. Pullboxes shall conform with ASTM A615 and C857.

C. Pullboxes shall provide conduit entrances on all four sides. Knockout panels or precast individual conduit openings may be used. On sides where no raceways are installed, provide knockout panels for future raceway installation. Provide knockout(s) or sleeves for ground rods.

D. Pullbox covers shall be identified by inscription according to the Contract Drawings.

E. In pullboxes, provide heavy duty non-metallic cable racks with adjustable arms. Cable racks shall be compatible for use with the specific pullbox. Inserts for installation of cable racks shall be installed as an integral part of the manhole by the manufacturer and attachment hardware shall be stainless steel conforming to AISI, Type 316. Do not use bolts or studs embedded in concrete for attaching racks. Unless otherwise specified, set racks and inserts on not greater than 3-foot centers around the entire inside perimeter of the manhole/pullbox, arranged so that all raceway ends are clear for future cable installation. Manhole/pullbox stanchions shall have two 4 inch arms each. Manhole/pullbox racking shall comply with the clear working space requirements of IEEE C2 Rule 323B.

F. For each pullbox, provide one pulling iron embedded in the concrete wall near the floor opposite each raceway bank entering manholes/pullboxes in each corner unless otherwise indicated. Use ¾ inch round stock securely fastened to the overall steel reinforcement before concrete is poured.

G. Pullbox hardware shall be hot-dip galvanized steel.

H. Damp-proofing compound shall be factory applied, one coat, on all outside surfaces. Damp-proofing shall be coal-tar bitumastic.

I. Manholes for traction power system shall be provided in accordance with 34 21 01, Traction Power Basic Electrical Materials And Methods.

PART 3 – EXECUTION

3.01 GENERAL

A. Location of pullboxes are shown in Contract Drawings.

B. Install longer side of the pullboxes parallel to tracks.

C. Excavation and Bedding

1. The excavation shall be made to a depth to allow for the overall assembled height and bedding of pullboxes as shown on the Contract Drawings. Provide and install risers as shown to bring the pullbox to the required finish grade.
2. Over excavate at least 12 inches around the sidewalls of the manholes/pullboxes and handholes for ease of installation and to prevent sluffage.
3. In mechanically stabilized earth (MSE) wall areas with greater than 12 feet in depth of Class 1 structural backfill, 3/4-inch crushed rock and filter fabric will not be required under the pullbox.
4. Bedding for pullboxes shall consist of 1-foot minimum depth of 3/4-inch minus crushed rock, graded level, and compacted in accordance with Section 31 00 00, Earthwork.

D. Inspection and Setting

1. Excavation must be completely dewatered before setting structures in accordance with Section 31 23 19, Dewatering.
2. Notify the Engineer in advance of the installation of each structure.
3. Assemble by lowering each section into the excavation.
4. Lower the base section first, set level and firmly position before placing intermediate and top sections.
5. Ensure that the seal surfaces between sections are clean and that the gaskets are in place.
6. Completed pullbox shall be inspected by the Engineer before backfilling.

E. Backfilling

1. Backfill around all structures in accordance with Section 31 00 00, Earthwork. Backfill shall consist of approved compactable material such as 3/4-inch minus crushed rock, sand or clean earth fill containing no rocks larger than 3/4-inch. No voids shall remain between the pullbox walls and native soil excavation.

F. Grouting

1. Grout risers, covers and raceway entering manholes/pullboxes and handholes with non-shrink cement grout consisting of 2 parts sand and 1 part cement and sufficient water to form heavy plastic slurry.
2. Apply grout in a manner to ensure filling of all voids in the joint being sealed.

3.02 GROUNDING

A. All pullboxes shall be grounded in accordance with Section 26 05 26, Grounding and Bonding for Electrical Systems, and as shown on the Contract Drawings.

B. In each pullbox, all metallic components, including covers and cover mounting frames, metallic raceway grounding bushings, cable racks and inserts shall be grounded. Provide a minimum of two driven ground rods in opposite corners. Connect the rods to all metallic parts using a copper bonding conductor. Grounding conductor shall be exothermically welded or connected with approved Burndy Irreversible Compression Fittings to the ground rod. Connection to other metallic parts may be by exothermic welding or bolting using stainless steel hardware.

3.03 IDENTIFICATION

A. Identify each pullbox by inscription “VTA-C” or “VTA-P” on the pullbox lid. Letters shall be 1.25 inches in height.

B. Identify each pullbox by inscribing the pullbox name on the inside of the pullbox with the numbers shown on the Contract Drawings and as required by this Section. Letters shall be 3-inches in height, and stenciled with black paint on white background or engraved on a placard with black letters on a white background. Identification shall be placed just below the cover on the inside wall. Placards shall be secured with stainless steel bolts. Paint shall be exterior latex masonry type.

C. Identify each ductbank entering a pullbox as shown on the Contract Drawings. Numbers shall be 2-inches high stenciled with black paint on white paint background or engraved on a placard with black letters on a white background. Placards shall be secured with stainless steel bolts. Paint shall be exterior latex masonry type.

3.04 CABLE SUPPORTS

A. Cable supports shall be installed by the Contractor per manufacturer instructions.

END OF SECTION 26 05 44

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SECTION 26 05 45

SYSTEMWIDE ELECTRICAL CABLE TROUGH

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for providing a complete prefabricated cable trough system flush with top of grade. Trough system consists of trough, cable dividers, covers, and associated material, for installation of power, communication and signal cables.

1.02 RELATED SECTIONS

A. Section 01 78 39, Project Record Documents

B. Section 26 05 00, Common Work Results for Electrical Systems

C. Section 26 05 34, Systemwide Electrical Conduits for Systems

1.03 REFERENCED STANDARDS

1.04 SUBMITTALS

A. General: Refer to Special Conditions for submittal requirements and procedures.

B. Submit product data for the following:

1. Copies of fabricator's records showing data and conditions relating to manufacture of each trough unit, and including type of fabricator's building or enclosure, form material, curing procedures (steam or water), temperature ranges (of steam or water), air entrainment content, water- cement ratio and method of finishing units.
2. Copies of certified tests conducted by an "Accredited Authoritative Testing Laboratory" for type acceptance of units.

C. Detail drawings of units, including:

1. Physical dimensions;
2. Reinforcement;
3. Covers;
4. Alignment holes and pin hefting hooks;
5. Internal dividers and method of fastening to trough assembly.
6. Details of type of sealing compound for joints, holes and conduits.

D. Record Documents: Provide copies of all approved submittals, specified herein, for record purposes in accordance with the requirements of Section 01 78 39, Project Record Documents.

1.05 QUALITY ASSURANCE

A. Furnish trough material and components new and free from manufacturing defects.

B. Install trough systems in compliance with manufacturer's specifications and recommended installation practices.

1.06 MEASUREMENT AND PAYMENT

A. Measurement:

1. Systemwide Cable Trough shall be measured by the Linear Foot.

B. Payment:

1. The contract price paid per Linear Foot for Systemwide Cable Trough shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in placing prefabricated cable trough complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 GENERAL

A. Furnish complete trough system as specified herein, including covers, fasteners, and associated material.

B. Determine the amount of trough required in accordance with these Specifications and as shown on the Contract Drawings.

2.02 TROUGH AND COVERS

A. Furnish trough units which present a smooth finish on interior and exterior surfaces.

B. Furnish trough in section lengths in accordance with manufacturer's standards and as approved.

C. Trough units shall be constructed of high density, non-porous polymer concrete or other type of concrete as approved. Trough cover shall have a skid-resistant surface.

D. Trough units and covers shall be rated to support pedestrian loads.

E. Trough units and covers shall be equipped with holes designed specifically for handling purposes. After initial installation, seal holes as specified herein.

F. Furnish trough in lengths to facilitate grounding of trough material where required. Trough cover material shall be non-conducting.

2.03 INTERNAL TROUGH CABLE DIVIDERS

A. Furnish dividers constructed of fiberglass, and fasten to bottom of each section of trough.

B. Where sections of troughs containing dividers are butted together, align dividers.

C. Dividers and fastening material shall present a smooth finish which will not damage cable.

2.04 SEALING MATERIALS

A. After installation of adjacent cable trough sections is complete, seal butt joints and trough covers using silicone sealing compound or neoprene gasket in accordance with manufacturer's recommendations and as approved.

B. Seal holes within each section of trough cover.

C. Installer shall use butt joints and cover seals to prevent sand, gravel, and foreign debris from entering trough system.

PART 3 – EXECUTION

3.01 GENERAL

A. Furnish and install a complete pre-fabricated cable trough system on top of aerial guideway. Trough system consists of trough, cable dividers, covers, and associated material, for installation of power, communication and signal cables.

B. Maintain trenches free of construction debris, rock, or earth. Remove foreign material from channels prior to installing cables and covers.

C. Furnish and install coverings constructed of wood, steel or other material as approved to protect troughs against damage in areas of working cranes, backhoes, front end loaders, or other heavy equipment.

3.02 TROUGH INSTALLATION

A. Install troughs using mechanized equipment with lifting sling or harness or other approved lifting device in accordance with manufacturer’s recommendations.

B. Butt join sections together and align using alignment pins.

C. Seal butt joints according to manufacturer's recommendations and these Specifications.

D. Core-bore holes on site in side of trough system, halfway between top and bottom of trough side wall, to accommodate lateral conduits. Quantity of holes per section shall not exceed manufacturer’s recommendations. Seal conduit trough intersections using weatherproof sealer approved by the Engineer. Install conduits in accordance with Section 26 05 00, Common Work Results for Electrical Systems and Section 26 05 34, Systemwide Electrical Conduits for Systems.

E. Install end plugs of same material as trough units in exposed trough ends and seal in accordance with these Specifications.

3.03 TROUGH CUTTING

A. For length adjustments and angle cuts, cut troughs and covers on site to ensure a true and proper fit, using standard concrete cutting equipment and methods in compliance with manufacturer's recommendations.

B. Bevel interior angles after cut sections of trough are butted together.

C. Upon completion of installation of trough system as determined by the Engineer, backfill troughs in accordance with these Specifications. Backfill and compact simultaneously on both sides of trough in successive layers not exceeding eight inches.

D. Install and seal covers after approval of cable installation.

3.04 CABLE INSTALLATION

A. Install cable within trough system in accordance with these Specifications and as shown on the Contract Drawings.

B. Utilize the following criteria where cable is installed within sections of troughs containing cable dividers:

1. Use internal area of trough from cable divider to track side of troughs for local cable runs such as track leads, switch cable and signal cable.
2. Use remaining internal area(s), from cable divider to the field side of the trough for express cables and communication cables.

END OF SECTION 26 05 45

SECTION 26 05 48

SEISMIC CONTROLS FOR ELECTRICAL WORK

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes seismic restraints and other earthquake-damage-reduction measures for electrical components. It applies to and complements optional seismic-restraint requirements in the various electrical component Sections of these Specifications.

1.02 DEFINITIONS

A 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.

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

1.03 SUBMITTALS

A. Refer to Section 26 05 00.

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

C. Shop Drawings: For components, physical arrangements, and installation details not defined by Drawings. Indicate materials, details, and layouts.

D. Qualification data.

E. Field quality-control test reports.

1.04 QUALITY ASSURANCE

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

1.05 COORDINATION

A. Coordinate layout and installation of seismic bracing with structure, architectural features, mechanical, fire-protection, electrical, and other systems.

B. Coordinate concrete bases with structural system.

1.06 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. B-Line Systems, Inc or approved equal.
2. Thomas & Betts Corp or approved equal.
3. Unistrut Corporation or approved equal.

2.02 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.

2.03 ANCHORAGE AND STRUCTURAL ATTACHMENT COMPONENTS

A. Structural Safety Factor: Strength in tension and shear of components shall be at least twice the maximum seismic forces for which they are required to be designed.

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.

2.04 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. Hanger Rod Stiffeners: Slotted steel channels, installed vertically, with internally bolted connections to hanger rod.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install seismic restraints according to applicable codes and regulations and as approved by authorities having jurisdiction, unless more stringent requirements are indicated.

B. Install structural attachments as follows:

1. Use bolted connections with steel brackets, slotted channel, and slotted-channel fittings to spread structural loads and reduce stresses.

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

3. Attachments to Existing Concrete: Use expansion anchors.

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

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

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

7. Attachments to Wood Structural Members: Install bolts through members.

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

C. Install electrical equipment anchorage as follows:

1. Anchor panelboards, switchboards, transformers, fused power-circuit devices, control, and distribution units as follows:

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

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

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

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

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

D. Install seismic bracing as follows:

1. Install bracing according to spacings and strengths indicated by approved analysis.

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

3. 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.

E. Accommodation of Differential Seismic Motion: Make flexible connections in raceways, cables, wireway, cable trays, and busway 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.

3.02 FIELD QUALITY CONTROL

A. Reinspection: Correct deficiencies and verify by reinspection that work complies with requirements.

B. Provide written report of tests and inspections.

END OF SECTION 26 05 48

SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing and installing identification for electrical systems from service point to lights, TVMs, PIMs, CIDs, PASs, Cameras, ETELs and other electrical equipment and irrigation controller cabinets via service cabinets;

B. Electrical work for the irrigation controller cabinet and related to the wiring fed from the irrigation controller cabinet is covered in Section 32 84 00, Irrigation Systems.

C. Refer to Section 26 05 00, Common Work Results for Electrical Systems for additional requirements.

1.02 REFERENCED STANDARDS

A. Insulated Cable Engineering Association (ICEA)

B. City of San Jose Standard Specifications (CSJSS), Sections 86

C. City of San Jose, Standard Details for Public Works Construction, 1992; General, Roadway Geometrics, and Electrical - Signals and Lighting http://www.sanjoseca.gov/publicWorks/Details_Specs/

D. County of Santa Clara Roads and Airports, Standard Specifications, May 2000.

1.03 SYSTEM DESCRIPTION

A. Provide lighting systems, communications systems, fire alarm system and irrigation controller nameplates, labels, wire markers, and warning tape, and lockout devices as indicated on the drawings, and specified in Section 86 of the City of San Jose Standard Specifications and herein.

1.04 SUBMITTALS

A. Refer to Section 26 05 00, 1.06, Submittals.

B. Submit electrical identification schedule including list of wording, symbols, letter size, color-coding, tag number, location, and function.

C. Provide shop drawings or mock ups of labels, wire markers, and warning tape, and lockout devices.

D. Contractor to submit for approval "Redlined" drawings showing final cable numbering, routing and spare conduits in accordance with the requirements included in Section 01 78 39, Project Record Documents.

1.05 MEASUREMENT AND PAYMENT

A. Full compensation for work under this section shall be considered as included in the prices paid for various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Brady sleeve type wire marker or approved equal.

B. Brady underground warning tape or approved equal.

2.02 MATERIALS

A. Underground warning tape shall be 4 inch wide plastic tape, detectable type, colored red for buried electrical lines and orange for fiber optic lines.

B. Lock out hasps shall be reinforced nylon hasp with erasable label surface; size minimum 7.25 x 3 inches.

C. Nameplates and Labels shall be furnished in accordance with VTA, City or County Standards as required.

D. Conduit and raceway markers shall be furnished in accordance with VTA, City or County standards as required.

1. Legend:
    a. As indicated on the conduit schedule.

E. Wire Markers shall be furnished in accordance with VTA, City or County Standards.

1. Legend:
    a. Power and Lighting Circuits: Branch Circuit or feeder number as indicated on the Drawings.
    b. Control Circuits: Control wire number as indicated on schematic and interconnection diagrams.

2.03 EXAMINATION

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

2.04 PREPARATION

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

PART 3 - EXECUTION

3.01 INSTALLATION

A. Special Techniques

1. Numbering electrical equipment
    a. Contractor shall place the numbers and edge sealer on the equipment as required by the Engineer.
    b. Reflective numbers shall be applied to a clean surface. Only the edges of the numbers shall be treated with edge sealer.
    c. Where shown on the Drawings, self-adhesive equipment numbers shall be placed for all electroliers, and service pedestals. On electroliers, the numbers shall be placed as shown on Standard Plan ES 6A.
    d. Where new numbers are to be placed on existing or relocated equipment, the existing numbers shall be removed.
    e. Numbering electrical equipment shall conform to the details shown on the Drawings, the City of San Jose Standard Specifications and Standard Details, the County of Santa Clara Standard Specifications as required and these technical specifications.

B. Conduit Identification

1. Installation of warning tape shall not be required for conduit installed by directional boring or for conduit trenched with PCC backfill.
2. Install underground warning tape along length of each underground conduit, raceway, or cable 6 to 8 inches below finished grade, directly above buried conduit.

C. Wire Marker/Conductor Identification

1. Install permanent cable tags at both ends of each cable. Each tag shall identify the origin and destination of the cable and the number and sizes of conductors. Install permanent wire tags at all conductor terminations, including spares. Tags shall provide a unique identification of origin and destination of the conductor and its circuit number.
2. Ground conductors shall have green insulation or be bare copper.
3. Wire designations shall consistently conform to an overall scheme prepared by Contractor and approved by the VTA to indicate location, circuit, device, wire number, terminal branch, position, etc. Letters and numbers shall be used.

D. 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, or adhesive.
3. Install nameplates for each control panel and major control components located outside panel with corrosive-resistant mechanical fasteners, or adhesive.
4. Secure nameplate to equipment front using screws or adhesive.
5. Secure nameplate to inside surface of door on recessed panelboard in finished locations.
6. Install nameplates for the following:
    a. Switchboards.
    b. Panelboards.
    c. Transformers.
    d. Service Disconnects.

E. 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.

F. Wire Marker Installation

1. Install wire marker for each conductor at panelboard gutters, pull boxes, outlet and junction boxes and at each load connection.
2. Mark data cabling at each end. Install additional marking at accessible locations along the cable run.

3.02 FIELD QUALITY CONTROL

A. Inspection

1. Inspect identification for complete and durable adhesion and mounting with the correct information easily visible.

END OF SECTION 26 05 53

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SECTION 26 05 73

POWER SYSTEM STUDY

PART 1 - GENERAL

1.01 SUMMARY

A. The work under this section of the Specifications consists in general of furnishing all labor, materials, services, and supervision required for a complete Power System Study for electrical systems at Story Station and Eastridge Station. Electrical contractor is responsible for study.

B. Systems and equipment to include but not be limited to the following:

1. PG&E Service equipment
2. Low Voltage distribution equipment and devices
3. All system impedances

C. Study to include but not be limited to the following:

1. Complete fault calculations
2. Time-current coordination curves
3. Device evaluation
4. Arc flash calculations and labels
5. Executive summary and complete explanatory information and narrative, including identification of all deficiencies
6. Preliminary fault study

1.02 RELATED DOCUMENTS

A. General Conditions and Division 1 shall apply to work under this section.

1.03 REFERENCES

A. ANSI C37.13-1981 (UL 489-1991)

B. IEEE C37.13-1990

C. ANSI C37-.01-1979

D. IEEE standard 242 and 399

E. Arc flash: NFPA 70E; NEC 110.16; ANSI Z535.4

F. Most recent industry standards and publications to apply

1.04 REPORT SUBMITTALS

A. General

1. Submit annotated copy of this specification with the bid to indicate compliance or proposed means of achieving equivalency. If deviating from the specified product or method, describe equivalent equipment and methods.
2. Submittal for report documentation in Adobe .pdf digital format.

3. Each page of the submittal is to be numbered sequentially. Tabs must be used to sub- divide the submittal and restart the sequential numbering. Provide complete index to all multi-section submittals.
4. Provide table of contents.
5. All submittals to be provided with sufficient clarity to avoid blurred or unreadable text. Scanned images are not acceptable.

1.05 STUDY SUBMITTAL AND REVIEW

A. Study to be completed in 3 phases:

1. Submit preliminary fault study to evaluate withstand ratings and selectivity requirements for specified equipment.
2. Submit coordination study after receipt of planned cable and bus lengths, raceway types, transformer impedances, and finalized equipment submittals. Study to be approved by Engineer prior to NETA testing of overcurrent protective devices. Report submittal to include time-current curves (TCCs) to demonstrate that devices are properly coordinated in all operating scenarios. Include table of planned arc flash hazard values and SKM simulation files in native file format.
3. Submit final coordination/arc flash study after receipt of actual cable and bus lengths, raceway types, and transformer impedances. Study to be approved by Engineer prior to installation of arc flash labels. Update coordination study report and include an appendix listing all changes to device settings that need to be made by installing contractor. Include PDF of all arc flash warning labels and SKM simulation files in native file format.

B. Submit complete SKM digital files in native program format. Complete package to include files for project, one lines and TCCs, arc flash label template, custom data block template, project library, as well as all other program files.

C. Submit the following for review:

1. Executive summary for each report with recommendations, analysis, and summary
2. Complete actual impedance data for installed components (may be submitted as a data block applied to one lines rather than a tabular form)
3. Device evaluation report
4. Arc flash report and labels
5. Time current coordination: graphical representation with complete table of device settings
6. All device settings
7. Complete SKM database files suitable for execution on any PC with licensed SKM software.
8. Provide recommendations to achieve optimal coordination and operating conditions

1.06 SKM MODEL REQUIREMENTS

A. Study to be modeled as a single project in SKM.

B. Project filename to be 3 letter site acronym and number. For example, STO1.prj.

C. Prefix all component names with the 3 letter and 1 number designator (STO1). For example, “SB-1A” shall be named “STO1 SB-1A.”

D. Component naming convention to be as follows:

1. Main Breakers – MB-'Downstream Bus name'-'Breaker name (Optional)'. Ex: STO1 MB-MS-1-CB1
2. Feeder Breakers – FB-'Downstream Bus name'. Ex: STO1 FB-SB-1A
3. Cables – CBL-'Downstream Bus name'. Ex: STO1 CBL-SB-1A
4. Buses – Match one-line names.
5. Other equipment – Match one line names.
6. Do not use punctuation or spaces to differentiate between line/load or primary/secondary component names.

E. All equipment to have a custom data block field with installed location. For example, include hall and row designator for equipment installed in data hall, room name for other equipment.

F. Include a dedicated one-line for the complete system. All components to only be shown in a single one-line, with the exception of components at a one-line link.

G. Use links for all electrical connections between one-lines. Show the same component on each side of a link between one-lines.

H. Add annotation on one-line next to each MS with equipment number and system phenolic label color. For example, annotation shall read MS1 – Color.

I. No floating, disconnected, or out-of-service components. Exception to in-service requirement: breakers that are connected but open.

J. Symbol selection for circuit breaker to be the symbol with the text "OPEN" when in the "out of service position.

K. Arrange and space components such that any standard data block and all custom datablocks are legible and not obscured. All datablocks and nametags to be positioned and oriented to their defaults.

L. Project file to be submitted with data state for all components set as "complete".

M. In component editor, "Main, Include in Arc Flash Line Side" box shall remain unchecked for all equipment.

N. In component editor, "Do Not Size" box shall be checked for all applicable equipment.

O. Each piece of equipment to have an individual TCC for phase and ground (where applicable). TCC convention is to include the equipment's upstream protective device with the label on the right, and labels for the equipment's components on the left. Arrange labels such that all annotation information is legible. Each TCC to be titled with the equipment name and protection curve type (phase or ground). TCC reference voltage to match main equipment voltage.

P. TCC naming convention to be as follows:

1. 'Unique Number'-'Equipment Name'-'Optional Identifier'. Ex: 01-MSB-1-Utility, 05-HMD-4A.

Q. Adjust protective device settings such that all devices coordinate properly with upstream and downstream devices. All equipment unable to achieve complete device coordination to be highlighted in submittal review and must be explicitly approved by the Engineer.

R. While preserving device coordination, manufacturer's recommended clearing times, and inrush current allowances, adjust protective device settings for all equipment as low as possible to reduce arc flash hazard. All equipment with a calculated incident energy >40Cal/cm^2 to be highlighted in submittal review and must be explicitly approved by Engineer.

S. Actual utility characteristics to be used. Assuming an infinite bus for utility fault contribution is not acceptable for final study submittal. Utility connection in SKM file to be immediately upstream of first Owner component.

T. Coordination with utility protective devices is required. Utility devices immediately upstream of Owner's equipment to be shown in electrical system study.

U. Minimum device separation for clearing time where dictated by utility to be accommodated and must be documented in the study.

V. Equipment and cable impedances to be based on ANSI/IEEE and other related industry standards.

W. Actual installed raceway type and length to be used for final study submittal. Preliminary review submittals to have estimated raceway data.

X. Actual installed transformer impedance to be used for final study. Preliminary review submittals to have nominal impedance as specified for equipment. Include photos of all transformer nameplates showing actual impedances as an appendix to final report.

1.07 OPERATION AND MAINTENANCE DATA

A. Provide final study based on as-built conditions.

1.08 QUALITY ASSURANCE

A. The short circuit, protective device coordination, and arc flash study to be conducted within the guidelines established by ANSI/IEEE standard 141-latest edition and IEEE 1584.

B. The power system study shall be performed using the latest version of SKM Power*Tools software by SKM Systems Analysis, Inc.

C. The arc flash labels shall meet all requirements of the latest edition of NFPA 70E.

1.09 MEASUREMENT AND PAYMENT

A. Measurement: Power System Study (Story Station) and Power System Study (Eastridge Station) shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Power System Study (Story Station) and Power System Study (Eastridge Station) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in the Power System Study (Story Station) and Power System Study (Eastridge Station) complete in place, as per the drawings, as specified in these Technical Specifications, and as directed by the VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide complete power study signed by a Professional Electrical Engineer registered in the State of California in accordance with NETA section 6.

1. Short circuit and protective device coordination study
2. Arc flash report and study
3. Arc flash labeling for all service and distribution equipment

B. Provide executive summary

1. Report to include:

a. Single line with all applicable electrical apparatus rating indicated
b. Calculation method
c. Assumptions
d. Calculation results in single line diagram form and tabulation
e. Input data
f. Time-current curves for all devices
g. Fuse sizes
i. Recommended settings for preliminary report, as-left settings in final report
j. Verification of all interrupting rating of equipment
k. Conclusions and recommendation

C. The study to include settings of all medium voltage equipment

D. Include utility company fault contribution data. Provide service fault contribution data provided by utility company as an appendix to report.

E. Use field-installed cable measurements. Provide legible copies of cable pull sheets with all wire lengths as an appendix to report.

F. Include required PG&E pad-mount transformers, all cables and field measured lengths, all low voltage panelboards, UPS systems, transformers, motor feeders and circuits for all motors, all mechanical equipment control panels, and fused disconnects.

G. Perform device coordination considering Normal utility.

H. Generate all arc flash labels and attach to all equipment. Non-fused disconnects do not require labels.

J. Provide settings for all adjustable overcurrent devices prior to device testing.

2.02 SHORT CIRCUIT STUDY

A. Provide complete short circuit study for all normal operating scenarios.

B. Include 3-phase and line-to-ground fault values.

2.03 DEVICE EVALUATION TABLE

A. Provide tabulation for all devices.

B. Indicate ANSI ratings and calculated fault duties. Indicate pass or fail for each piece of equipment evaluated.

2.04 COORDINATION STUDY

A. Provide all device settings

B. Provide tabulation for settings and plotted TCCs

C. Include ground fault and phase devices on separate plots

D. Provide color coded plots. Separate color for each plotted device

2.05 ARC FLASH STUDY AND LABELS

A. Arc flash Incident energy to be calculated for all equipment.

B. Arc flash labels to be based on the worst-case condition.

C. Arc flash label value point to be taken from the worst case of line side of the input breaker, load side, or bus, for equipment without cubicle separation.

D. All fault clearing times to be calculated based on the protective device characteristics, except where limited by the specified study max arcing time.

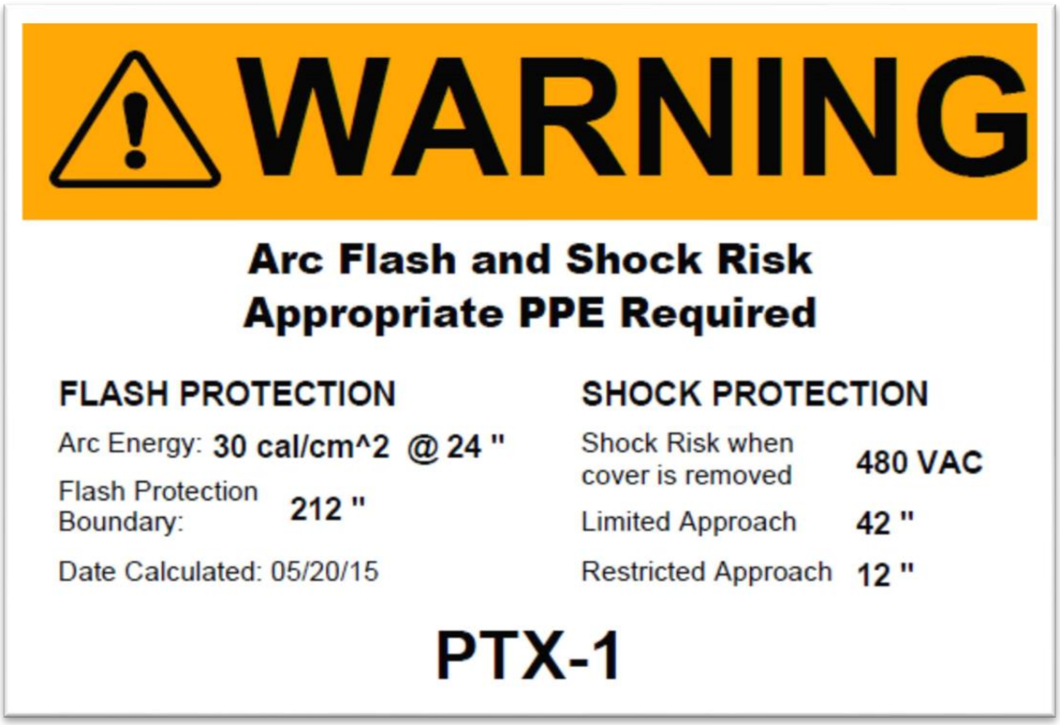
E. Arc Flash Study Options:

1. Equipment Below 240V: Report Calculated Values From Equations.
2. Use Global Arcing Time of 2 seconds for all voltages.
3. Report Option: Bus + Line Side + Load Side, Worst Case Only.
4. Line Side + Load Side Fault Contribution Option: Line + Load Sides.

F. Arc flash labels displaying the incident energy and other required information be applied as specified in the latest edition of NFPA 70E. Include device name and date printed on each label. Labels to be in English.

G. Electrical contractor to print and install labels prior to Level 5 commissioning. All labels to be 4”H x 6”W and printed on a weatherproof backing. Labels to have orange “Warning” header.

H. Label template example shown below.



PART 3 - EXECUTION

3.01 GENERAL

A. Provide preliminary fault study report within timeframe requested by Engineer.

B. Implement approved settings on programmable and adjustable trip devices prior to NETA device testing.

C. Apply arc-flash labels to all equipment.

END OF SECTION 26 05 73

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SECTION 26 09 23

LIGHTING CONTROL SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. This section includes requirements for furnishing, installing, testing and integrating a fully functional and complete Lighting Control system for the Story Station and Eastridge Station as indicated on the Plans.

1.02 MEASUREMENT AND PAYMENT

A. Full compensation for work under this section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefor.

1.03 QUALIFICATIONS

A. Contractor shall have a C-7 Low Voltage Systems Contractor License to perform low voltage installation work and adhere to all applicable codes and safety requirements.

B. Contractor shall have necessary qualifications to complete the work, and show history of completing projects of comparable size and complexity.

1.04 SUBMITTALS

A. Refer to Section 26 05 00.

B. 30 days prior to ordering materials, the Contractor shall submit a list of all electrical equipment including lighting controllers, dimming controller, data enablers, conductors, cables, patch cords, and mounting hardware, and other accessories as required, to be used on the project, accompanied by manufacturer's literature and drawings for each item, including the manufacturer's recommended methods of installation.

C. A typical functional description, block diagram, interconnection and wiring diagram for proposed Lighting Controller equipment and systems including power and communication interfaces with the existing VTA network.

D. Configuration and Testing Procedures for Engineer's review and approval. This shall be submitted a minimum of 14 days before the proposed commencement of testing.

E. Documented Test Results for Engineer review and approval.

1.05 WARRANTY OF WORK

A. Warranty period shall commence at Project Acceptance.

B. Warranty work shall include materials, installation and construction products.

C. Contractor shall provide a contact name and phone number for warranty work.

D. Response time for warranty work shall be within 48 hours.

E. Contractor shall remove and replace any equipment components that fail during the warranty period at no additional cost to VTA.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Lighting Controller

1. The lighting controller shall allow for a lighting sequence to be deactivated by a timer.
2. The lighting controller shall have an internal real-time clock that continues to operate when external power is absent. It shall be capable of adjusting for Daylight Savings Time automatically and can be updated over the internet using Network Time Protocol.
3. The lighting controller shall be able to calculate sunrise and sunset times based on longitude and latitude information and use these as triggers.
4. The lighting controller shall allow lighting to be programmed as separate zones, with independent triggering and manual intensity control.
5. The lighting controller shall support multiple timelines.
6. The lighting controller shall have a recessed switch for resetting the unit without removal of power.
7. The lighting controller shall have an internal watchdog feature that will restart the unit in the event of program failure.
8. The lighting controller shall be supported by programming software running on either a PC or MAC platform.
9. The unit shall be entirely solid-state with no moving parts, fans or hard disc drives and operate in a temperature range from 32 to 122°F.
10. The unit shall be ET/cETL listed and CE compliant.
11. The lighting controller shall be provided with a 5-year manufacturer warranty.
12. The lighting controller shall be PHAROS LPC2 or approved equal.

B. Dimming Control Panel

1. The dimming control shall be able to handle a fully loaded electrical circuit-up to four dimming legs per module.
2. The dimming control shall have field settable leading (forward phase) or trailing (reverse phase) edge dimming allowing unprecedented support of Electronic Low voltage and LED drivers.
3. The dimming control shall be prewired.
4. The dimming control shall be wired withmanufacturer cables.
5. The control enclosure shall be a NEMA-Type 1, IP-20 protection; #16 U.S gauge steel.
6. The control shall have 10 year power failure memory with automatic restoring of lighting to scene selected prior to power interruption.
7. The dimming control shall be UL listed and meet ANSI/IEEE standard 62.41-1980.
8. The dimming control shall have the 4-Circuit Apadtive Dimming Module (4A), 4-Circuit Switching (Relay) Module (XP) and the TVM Module.
9. The dimming control shall be Lutron model CCP-1X1AIT-120FT-CGP278 or approved equal.

C. Cables

1. All cables required for a complete system including CAT6, power cables, manufacturer's leader and jumper cables shall be provided per the Drawings.

D. Occupancy Sensors

1. The wall mounted occupancy sensors shall be push button programmable for adjusting time delays and operating modes. The wall mounted motion sensor shall be Sensor Switch WSX from Acuity Controls or approved equal.
2. The ceiling mounted occupancy sensor shall be the dual technology with PIR/Microphonics Detection and remotely configurable. The ceiling mounted motion sensor shall be nLight nCM PDT 9 from Acuity Controls or approved equal.

PART 3 - EXECUTION

3.01 EXAMINATION

A. All new equipment shall be inspected to ensure that it is free of defects, and that all components meet the requirements of this specification.

B. Prior to installation, Contractor shall bench test the system, and provide a demonstration of functionality to VTA for acceptance.

3.02 INSTALLATION

A. The manufacturer's Representative shall provide field support during installation, setup and testing of the Lighting Control system. All installation shall be in accordance with the manufacturer's specifications and recommendations.

B. All exposed wiring shall be installed in conduit. Leave wire slack in each junction box and terminating point.

C. No field drilling shall be done in poles or canopy structures to mount antennas or equipment.

3.03 SET UP AND OPERATION

A. POC Lighting

1. The lighting level for the POC shall be 10 FC.
2. The POC lighting shall be programmed for ON/OFF, 50% dimming during certain hours per VTA's schedule.

B. Station Lighting

1. The lighting level for the station pedestrian lights shall be 5 FC.
2. The station lights shall be programmed for ON/OFF and dimming per VTA's schedule.

C. Street Lighting

1. The lighting level goal for street lighting is 1.2 FC per RP-8, Table 2, Expressway medium pedestrian conflict.
2. Street lighting is set for on/off control by photocell.

3.04 TESTING AND ACCEPTANCE

A. All tests shall be witnessed and subjected to approval by the Engineer. Notify the Engineer at least 48 hours prior to testing.

B. The contractor shall in the presence of the Engineer conduct final testing to verify the system is complete and fully operational per the lighting schedule and requirements of VTA.

C. A training session shall be provided for use, maintenance and operation of the system. A notification of the proposed training session shall be provided in writing not less than 2 weeks in advance.

END OF SECTION 26 09 23

SECTION 26 22 00

DRY TYPE TRANSFORMERS

PART 1 - GENERAL

1.01 SCOPE

A. Furnish and install complete dry type, air cooled, step down transformers of ratings shown on the drawings.

B. The materials and equipment specified is to be new and listed by UL or equivalent agency

C. Furnish in accordance with the applicable specifications of the National Electrical Manufacturers Association, Institute of Electrical and Electronics Engineers, National Fire Protection Association, and the National Electrical Code.

D. NEMA TP-1 compliant transformers.

1.02 REFERENCED STANDARDS

A. Underwriters Laboratories (UL) 1561

B. National Electrical Manufacturers Association (NEMA) Publications

1. ST20 Dry Type Transformers for General Application Transformers, Regulations, and Reactors

2. TP 1 Transformer standard

3. TP 2 Test procedures

1.03 QUALITY ASSURANCE

A. Equipment dimensions to be no greater than what is shown on the drawings and must conform to the space allocated.

B. Vibration isolation to be accomplished through factory and field installation of isolators.

1.04 GUARANTEE AND WARRANTY

A. Refer to Section 26 05 00, 1.13 Warranty.

B. This guarantee also applies to services including Instructions, Adjusting, Testing, Noise, etc.

1.05 SUBMITTALS

A. Refer to Section 26 05 00, 1.07 Submittals.

B. Seismic anchorage design and calculations must be provided for all equipment weighing 400 lbs. or more and/or all equipment located four (4) feet or more in height above the supporting floor level. These calculations must be signed and stamped by a California licensed structural engineer with current registration.

C. Include the following specifications with the shop drawings:

1. KVA rating.
2. Primary and secondary voltage ratings.
3. Phases and cycles.
4. Connection diagram, i.e., Delta, Wye.
5. Taps.
6. Temperature rise by resistance.
7. Core and coil material.
8. Enclosure (NEMA type).
9. Sound ratings.
10. Applicable standards.
11. Manufacturer.
12. Mounting brackets.
13. Physical dimensions.
14. Impedance.
15. Wiring diagrams
16. Nameplates

1.06 MEASUREMENT AND PAYMENT

A. Full compensation for work under this section shall be considered as included in the prices paid for various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide KVA ratings and voltage characteristics designed for 60 Hz operation as indicated on the drawings.

B. Insulation system:

1. Open self-cooled dry type, designed for natural circulation of air through the windings.
2. 220°C insulation system (Class H).
3. Temperature rise: 115°C average rise above maximum ambient temperature of 40°C.

C. Coil: continuous wound aluminum

D. Windings, core, and coil assembly to be moisture resistant.

E. Impedance: NEMA standard.

F. Impedance range: 3% to 5%

G. Reactance: 2% minimum.

H. BIL: 10 kV for transformers less than 300 kVA; for transformers greater than 500 kVA provide NEMA standard

I. Grounding: core and coil assembly to be grounded to the enclosure by means of a visible flexible copper strap.

J. Mounting: transformers 75 kVA and less to be suitable for wall, floor, or trapeze mounting.

2.02 SOUND REQUIREMENTS (NON K-RATED)

A. Sound levels to be below recommended values established by ANSI and NEMA levels for self-cooled ratings:

1. Up to 50 kVA: 45 dB
2. 51 to 150 kVA: 50 dB
3. 151 to 300 kVA: 55 dB
4. 301-500 kVA: 60 dB

B. An integral sound absorbing system isolating the core and coil unit from the enclosure.

C. Provide integral sound control so that special sound reduction installations are not required.

D. Provide lower sound ratings where noted or indicated on the drawings

2.03 CORE

A. Non-aging steel sheets.

B. Core laminations: free of burrs and stacked without gaps. Clamped with steel angles.

C. Framing structure: rigid construction.

D. Low hysteresis and eddy current losses.

E. Magnetic flux density: significantly below saturation.

2.04 TAPS

A. Transformers to have a minimum of six (6) full load rated taps in the high voltage winding.

B. Taps in the higher voltage windings.

C. Two (2) 2-1/2% increments above normal nominal voltage (FCAN).

D. Four (4) 2-2/1% below nominal voltage (FCBN).

2.05 ENCLOSURE

A. Provide transformers with ventilated, drip-proof, heavy gage, sheet steel metallic enclosures.

B. Design to provide air cooling and prevent accidental contact with live conductors.

C. Locate the wiring compartment below the core and coil, cooled by air circulation or insulated from the core and coil with a thermal barrier.

D. Core and coil to be bolted to the base of the enclosure and isolated with rubber vibration-absorbing mounts.

E. No metal to metal contact between the core and coil and the enclosure except for ground strap.

F. Provide factory installed lugs designed for the termination of copper conductors. Locate lugs with respect to core and coils, so that standard cable will not be exposed to ambient temperatures above 50°C.

G. Finish: clean, degrease, prime and paint finished parts with baked-on synthetic enamel: ANSI 61 gray.

H. Listed (UL) for outdoor use when provided with manufacturer’s weather shield

2.06 ACCEPTABLE MANUFACTURERS

A. Square D Company

B. General Electric

C. Eaton/Cutler Hammer

PART 3 - EXECUTION

3.01 GENERAL

A. Read and apply the manufacturer’s recommendations for installation.

B. Obtain copy of manufacturer’s recommended field testing.

C. Verify equipment shipped exactly conforms to approved shop drawings and submittals.

D. Conduct visual inspection

1. Inspect equipment for signs of damage

2. Inspect case for damage and for foreign objects

3.02 RACEWAY CONNECTIONS

A. Use liquid tight flexible metal conduit for primary, secondary, and grounding electrode conductor raceways.

B. Attach incoming and outgoing conduits to the transformer case with approximately 18 inches of flexible conduit to reduce noise transmission. Provide separate grounding jumper.

3.03 VENTILATION

A. Install with adequate ventilation.

B. Maintain minimum of 6” free air space between transformer and adjacent walls and equipment.

3.04 VOLTAGE CHECK

A. Set all transformer taps under full load conditions.

B. No load secondary voltage: maximum of 126 VAC on 120 V base.

C. Full load conditions: 120 VAC on 120 volt base.

D. Adjust tap settings for optimum performance.

3.05 SUPPORT AND ANCHORAGE

A. Provide anchorage and bracing.

B. Install on noise and vibration isolation pads to reduce transmission of noise to structure.

3.06 CONCRETE PAD

A. Set transformers on 3 “high concrete pad where indicated.

3.07 IDENTIFICATION

A. Provide nameplate with equipment identifier consistent with the facility numbering system.

3.08 GROUNDING

A. Grounding electrode: provide separate grounding electrode conductor in conduit terminating to grounding electrode system.

B. Bond neutral to ground.

C. Ground the core and coil of the transformer to the enclosure with flexible grounding conductor.

3.09 FINAL CLEANING

A. Vacuum and clean transformer housing and interior.

B. Use touch-up paint on any scratched or marred surface.

END OF SECTION 26 22 00

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SECTION 26 24 16

PANELBOARDS

PART 1 - GENERAL

1.01 SUMMARY

A. Related Documents:

1. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. Provide the following panelboards:

a. Service entrance rated main distribution panelboards.

b. Distribution panelboards.

c. Lighting and appliance branch circuit panelboards.

d. Electronic Power Metering on panelboards per Section 2.05, when specified.

C. Coordinate with PG&E for requirements including access and metering of service entrance rated equipment.

1.02 REFERENCED STANDARDS

A. ANSI/NFPA 70 - National Electrical Code.

B. California Codes of Regulation, Title 24, Part 3.

D. Federal Specifications:

1. FS W-C-375 - Circuit Breakers, Molded Case, Branch Circuit and Service.

2. FS W-P-115 - Power Distribution Panel.

E. LBNL Facilities Department Lateral Force Design Criteria.

F. NFPA – National Fire Protection Association:

1. Standard for Electrical Safety in the Workplace (NFPA 70E)

G. NEMA – National Electrical Manufacturers Association:

1. NEMA AB 1 Molded Case Circuit Breakers.

2. NEMA PB 1 Panelboards.

3. NEMA PB 1.1 Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.

4. NEMA PB 1.2 Application Guide for Ground-fault Protective Devices for Equipment.

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

I. UL – Underwriters' Laboratories:

1. UL 67 Panelboards
2. UL 50 Enclosures for Electrical Equipment
3. UL489 Molded Case Circuit breakers and Circuit Breaker Enclosures

1.03 SUBMITTALS

A. Refer to Section 26 05 00, 1.06 Submittals.

B. Shop Drawings for equipment and component devices.

C. Outline and support point dimensions, voltage, main bus ampacity, integrated short circuit ampere rating, circuit breaker arrangement, sizes and numbering system.

D. Product description and data sheets on circuit breakers, trip units, accessories, locking hardware, shunt trip, under-voltage release mechanism, typical thermal-magnetic curves for each size and type circuit breaker or trip unit.

1.04 QUALITY ASSURANCE

A. Refer to Section 26 05 00, 1.07 Quality Assurance.

1.05 EXTRA MATERIALS

A. Keys: Furnish two door keys for each panelboard.

1.06 MEASUREMENT AND PAYMENT

A. Full compensation for work under this section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Cutler-Hammer or approved equal

B. General Electric or approved equal

C. Siemens or approved equal

2.02 BUS AND HARDWARE

A. Panelboards shall be completely factory assembled and equipped with a main circuit breaker and the type, size and number of branch circuit breakers, arranged and numbered as shown on the attached panel schedule(s). Panelboards shall be fully rated. Series rated panelboards are not acceptable.

B. All multi-pole breakers shall be common trip. Branch circuits shall be arranged using double row construction. Bus sequence shall be ABC top to bottom, left to right for both top and bottom fed panels. Provisions or space for future breakers shall be located at the bottom of the panel and be fully bussed, complete with the necessary mounting hardware. Use at least 100 ampere breaker-connecting bus straps and mounting hardware.

C. Where SPARE is indicated on the panel schedule(s), the specified circuit breaker and branch-circuit busing and mounting hardware shall be installed.

D. Where SPACE is indicated on the panel schedule(s), branch-circuit busing and mounting hardware shall be installed, ready for future installation of circuit breakers, furnished by others. A minimum of 20 percent spare pole spaces, grouped in multiple of three, shall be provided in each panelboard, for future installation. Provide single pole filler plates in the spaces, as required.

E. A nameplate shall be provided, and located near the top of the front trim on the exterior surface, listing panel type and ratings, as required by UL. Each circuit shall be permanently numbered to agree with the panel schedule, using plastic or metal buttons mounted adjacent to the breaker and secured by rivets or grommets with an engraved or depressed number. Adhesive numbering tape, painted numbers, or use of more than one number per breaker is not acceptable.

F. Main vertical bus bars shall be copper and plated per UL requirements. Bus bars shall be supported by glass-filled polyester-type insulators. Bolts used to connect current-carrying parts together, shall be accessible for tightening from the front of the panel. Bus bars shall be factory drilled and tapped with spacing arranged to permit breaker interchange, from the front, while the panel is energized.

G. Neutral bus shall be copper, 200 percent rated and insulated from the cabinet and other parts. It shall be rigidly mounted in the panel and shall be provided with a solderless cable connector for each circuit breaker and each space in the panelboard and the main connecting lug(s).

H. A copper equipment ground bus, of sufficient width and length, shall be solidly bolted and grounded to the enclosure at the bottom and shall leave clear space for the bottom cable entries. The bus shall have sufficient termination points in number to agree with branch circuits and spaces. A solderless connector, for No. 2 to No. 4/0 cable size, shall be bolted to the ground bus.

I. Copper bus bars shall be of sufficient size to provide a current density of not more than 1000 amperes per square inch of cross section, and not more than 200 amperes per square inch at bolted connections.

J. Minimum Short Circuit Rating for Bus Bracing: The bus shall be braced for the minimum symmetrical short circuit rating of the panel, as shown on the panel schedule.

K. Provide main bus pressure connectors (main lugs) and separately supported sub-feed pressure connectors (lug landings) where noted. Provide additional bottom raceway space to accommodate pressure connectors and lug landings. In no instance shall the gutter space be less than required by NFPA-70.

L. Pre-installed locking devices shall be provided for locking the main circuit breaker and each branch circuit breaker in the OPEN position, by means of a padlock. Locking devices shall not be removable from the front of the panel with the trim in place. Attachment of the locking device to the panel with adhesives is not acceptable.

2.03 CIRCUIT BREAKERS

A. Molded Case Circuit Breakers: NEMA AB 1, FS W-C-375; Provide bolt-on type circuit breakers with integral thermal and instantaneous magnetic trip in each pole (common trip type). Provide circuit breakers, UL listed as Type HACR, for air conditioning equipment branch circuits. Provide circuit breakers, UL listed as Type SWD, for lighting circuits. Provide UL Class A ground fault interrupter circuit breakers where specified on panelboard schedules and/or the Drawings.

B. Trip Unit:
   1. Instantaneous magnetic trips shall be accessible and adjustable from the front of the breaker on frame size 100 amperes.
   2. Trip units shall be interchangeable and adjustable for trip pick up and delay settings on frame size 225 amperes.
   3. Breakers sized 400 amperes and higher shall be equipped with solid state trip units with long-time, short-time, instantaneous, and ground fault (LSIG) tripping characteristics.

C. Breakers shall be rigidly mounted, separately removable and independent of trim plates for their support. Breakers shall be bolt on type.

D. Breakers shall be industrial grade with a minimum pole width of 1-inch (25.4 mm) and a minimum height of 5-1/2-inches (139.7 mm). Miniature circuit breakers are not acceptable.

E. The minimum symmetrical interrupting rating for molded-case circuit breakers shall be as specified on the panelboard schedule and/or Drawings. Series rated breakers are not acceptable.

2.04 CABINETS (BOXES)

A. All details of construction and methods of assembly shall meet the requirements of the "Enclosures for Electrical Equipment" of the Underwriters' Laboratories. The panel box shall not be less than 20" wide, 4.5 inches deep and of sufficient height to enclose the specified main and branch circuit breakers, buses, metering equipment and wire gutter. The panelboard enclosure shall be fabricated from code-gauge galvanized or galvanized-annealed steel without knockouts and with full front flange. The panel front shall be surface, as indicated on the drawings and fabricated from cold rolled steel. Surface mounted panel boxes shall be finished with an ANSI-61 light grey baked enamel. There shall be no screws projecting into the wiring raceways. The panelboard enclosure type shall be as specified on the panelboard schedule.

B. The front trim shall have full-length hinged outer door designed to expose the wiring raceways and breakers, when open. Another, inner hinged door shall expose breakers only, when open, making this a door-in-door construction. Both doors shall open to the right.

C. Both doors shall be provided with concealed butt or piano hinges. A suitable latch, which can be operated without tools, shall be provided to properly hold the inner door closed. For doors 30 inches high or less, a flush-type latch is satisfactory. For doors more than 30 inches high, a vault-type handle shall be provided with a three-point latch that holds the door closed at the top and bottom. The outer door shall be secured with at least 4 captured oval head machine screws.

D. A sturdy metal frame, with a clear plastic cover, for an 8-1/2 by 11 inch panelboard schedule, shall be attached inside of the panel door with the RTV adhesive.

E. Panel trim and doors, and surface mounted cabinets shall be thoroughly cleaned, given a rust-inhibiting treatment, and finished with an ANSI-61 light grey baked enamel.

F. Panelboards shall bear the Underwriters' Laboratories label.

2.05 ELECTRONIC POWER METERING

A. The panelboard shall be provided with the electronic power metering, where shown on the Drawings and/or panelboard schedule.

B. An advanced digital electronic energy meter shall be used. The meter shall measure the real-time RMS values of the phase currents (Ampere), Ampere demand, phase and line voltages (Volts), KW, KW demand, KWHR, KVA, KVA demand, KVAR, KVAR demand, power factor, and frequency.

C. A communications module shall be provided using a 10Base-T Ethernet and industry standard RS-485 serial bus.

D. The advanced digital electronic energy meter shall have non-volatile memory to record at least 100 time-stamped alarms and events.

E. Potential, control power and current transformers, shorting terminal block, fuse blocks and fuses shall be completely installed and wired to the energy meter in the panelboard.

F. The electronic power meter shall be Square D PowerLogic ION7350 or higher, Siemens Model 9350 or higher, Power Measurement Limited Model 7350 or higher, no substitutions.

2.06 EXCEPTIONS

A. The bidders shall list the exceptions taken from the specification with their quote. If no exceptions are listed with the bid, it is understood that the bidder shall meet the requirements of this specification and applicable Codes and Standards.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install panelboards plumb in conformance with NEMA PB 1.1. Where surface mounted, provide suitable supports and rack branch circuit conduits. Where mounted on concrete wall, install with 1/2 inches steel spacers behind the panel. Mounting attachments and connections shall be designed in conformance with the minimum lateral seismic force of 0.5W per CBC.

C. Incoming cable shall be adequately separated from load side cables. Appropriate wiring ducts shall be installed such that the interior has a neat appearance.

D. Provide filler plates for unused spaces in panelboards.

E. Provide typed [or neatly hand printed] 8-1/2 by11-inch circuit directory (panel schedule) for each panelboard, in the format as shown on the panel schedules. Revise directory to reflect circuiting changes required to balance phase loads.

3.02 FIELD QUALITY CONTROL

A. The VTA reserves the right to witness of the following tests conducted by the subcontractor. The VTA shall be notified in advance of these tests. NETA approved tests forms shall be used for the certified test report(s).

B. Visual and Mechanical Inspection: Inspect for physical damage, proper alignment, anchorage, and grounding. Check proper installation and tightness of connections for circuit breakers.

C. Test insulation of panelboard buses and circuit breakers (phase-to-phase and phase-to-ground) prior to applying power.

D. Measure steady state load currents at each panelboard feeder. Should the difference at panelboard between phases exceed 20 percent, rearrange circuits in the panelboard to balance the phase loads within 20 percent. Maintain proper phasing for multi-wire branch circuits.

3.03 POWER SUPPLY SERVICE

A. Contractor shall notify VTA 14 days prior to the anticipated date when the service meter will be ready for installation, to enable the utility to schedule its work well in advance of completion of the Project.

3.03 FINAL SUBMITTALS

A. After completion of the installation, wiring and testing, the Contractor shall submit the following information to the Engineer within two weeks of the equipment acceptance:

1. As-Built Panel Schedules.
2. Copy of the certified test report described in 3.02 above.

3.04 REFERENCE DRAWINGS AND PANELBOARD SCHEDULES

A. Include drawings numbers for the panelboard schedules. Schedules shall provide the following information:

B. Panelboard Number [ ]:

1. Panelboard type.
2. Number of phases.
3. Main bus ampacity.
4. Main circuit breaker trip rating.
5. Branch circuit breaker arrangement.
6. Branch circuit breaker trip sizes.
7. Flush or surface mounting.

8. Enclosure type.
9. Service entrance rating requirement.
10. Power Metering Requirement.
11. Circuit load.

END OF SECTION 26 24 16

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SECTION 26 27 26

WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. This section includes requirements for furnishing and installing wiring devices.

1.02 REFERENCED STANDARDS

A. National Electrical Manufacturers Association:

1. NEMA WD 1 - General Requirements for Wiring Devices.
2. NEMA WD 6 - Wiring Devices-Dimensional Requirements.
3. ADA – Receptacle and switch heights

1.03 SUBMITTALS

A. Refer to Section 26 05 00, 1.06 Submittals.

B. Product Data: Submit manufacturer's catalog information showing dimensions, colors, and configurations.

1.04 QUALIFICATIONS

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

1.05 EXTRA MATERIALS

A. Section 01 77 00 - Closeout Procedures: Spare parts and maintenance products.

B. Furnish two of each style, size, and finish wall plate.

1.06 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this Section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 RECEPTACLES

A. Manufacturers:

1. Pass and Seymour or approved equal

2. Hubbell or approved equal

B. Product Description: NEMA WD 1, General-duty general use receptacle.

C. Wall plate and Device Body: white or grey plastic.

D. Configuration: NEMA WD 6, type unless otherwise noted on the Plans

E. GFCI Receptacle: Convenience receptacle with integral ground fault circuit interrupter to meet regulatory requirements.

F. Weather-proof, GFCI with vandal resistant cover for shelters.

G. Fittings: Furnish manufacturer's standard couplings, elbows, outlet and device boxes, and connectors

2.02 WALL SWITCHES

A. Manufacturers:

1. Pass and Seymour or approved equal

2. Lutron or approved equal

B. Color: Ivory

C. Product Description: NEMA WD 1, General-Duty, AC only general-use snap or rocker switch.

D. Wall plate, Body and Handle: Ivory plastic with toggle or rocker handle.

E. Indicator Light: Lighted handle type switch

F. Ratings: Match branch circuit and load characteristics

PART 3 - EXECUTION

3.01 EXAMINATION

A. Section 01 12 16 – Work Sequence and Cooperation.

B. Verify outlet boxes are installed at a height per the ADA.

C. Verify wall openings are neatly cut and completely covered by wall plates.

D. Verify branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

3.02 PREPARATION

A. Clean debris from outlet boxes.

3.03 INSTALLATION

A. Install devices plumb and level.

B. Install receptacles with grounding pole on bottom.

C. Connect wiring device grounding terminal to outlet box with bonding jumper and to the branch circuit ground conductor.

D. 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.

E. Use jumbo size plates for outlets installed in masonry walls.

F. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, and on surface mounted outlets.

3.04 INTERFACE WITH OTHER PRODUCTS

A. Coordinate locations of outlet boxes provided under Section 26 05 33 to obtain mounting heights as specified and as indicated on drawings.

B. Install convenience receptacle 18 inches above finished floor.

3.05 FIELD QUALITY CONTROL

A. Section [26 05 00 – 1.07 Quality Assurance] [01 77 00 - Closeout Procedures]: Field inspecting, testing, adjusting, and balancing.

B. Inspect each wiring device for defects.

C. Verify each receptacle device is energized.

D. Test each receptacle device for proper polarity.

E. Test each GFCI receptacle device for proper operation.

3.06 ADJUSTING

A. Section 01 77 00 - Closeout Procedures: Testing, adjusting, and balancing.

B. Adjust devices and wall plates to be flush and level.

3.07 CLEANING

A. Section 01 77 00 - Closeout Procedures: Final cleaning.

B. Clean exposed surfaces to remove splatters and restore finish.

END OF SECTION 26 27 26

SECTION 26 28 16

DISCONNECT SWITCHES

PART 1 - GENERAL

1.01 WORK INCLUDED

A. The work covered by this Section consists of providing all labor, supervision, tools, materials, equipment and performing all work necessary to furnish and install disconnect switches.

1.02 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1. National Electrical Manufacturer's Association (NEMA) Publications:

a. KS 1 - Enclosed Switches

b. ICS 1 - General Standards for Industrial Control and Systems

c. ICS 2 - Industrial Control Devices, Controllers and Assemblies

d. ICS 6 - Enclosures for Industrial Control and Systems

B. Underwriters Laboratories, Inc. (UL) Publications:

1. 98 - Enclosed and Dead-Front Switches

2. 363 - Knife Switches

1.03 SUBMITTALS

A. Refer to Section 26 05 00.

B. Submit the following information for approval:

1. Manufacturer's Data and Shop Drawings:

a. Manufacturer's literature describing the product.

2. Fuse sizes, type and class.

3. Starter size and overload relay rating.

4. Overall dimension and weight.

5. Parts list and installation instructions.

1.04 MEASUREMENT AND PAYMENT

A. Full compensation for work specified in this section shall be considered as included in the prices paid for the various contract items of work involved and no additional payment will be allowed therefor.

PART 2 - PRODUCTS

2.01 DISCONNECT SWITCHES

A. Disconnect switches shall be heavy duty NEMA type HD, fused or non-fused, fully enclosed, NEMA 1 for indoor installation and NEMA 3R for outdoor installation. Fused switches shall be provided with rejection clips and fuses rated as required by the manufacturer of the equipment that is to disconnect.

B. Switch mechanism shall be of the quick-make and quick-break type. Switches shall be provided with a cover interlock to prevent opening of the switch door when the switch is in the "on" position. Means of defeating the interlock mechanism shall be provided to allow authorized personnel access to the switch interior with the switch in the "ON" position.

C. Switch enclosure shall be fabricated from code gauge sheet steel or code gauge galvanized steel as applicable to meet the requirements of NEMA 1 and 3R enclosures.

D. Padlocking provisions shall be provided for locking the disconnect switch in the "off" position with a minimum of 3 padlocks.

E. Disconnect switch shall be horsepower rated with current carrying ampacities as indicated on the Drawings.

2.02 ELEVATOR DISCONNECT SWITCH

A. The elevator disconnect switch must have a mechanically interlocked auxiliary contact for elevators with automatic recall. It must have a Fire Safety Interface Relay and a Fire Alarm Voltage Monitoring Relay.

B. The elevator disconnect switch must be Eaton ES-3-T1-R1-F3-D-N-B or approved equal.

2.03 ACCEPTABLE MANUFACTURERS

A. Siemens ITE, Square D, General Electric, Eaton Cutler-Hammer or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Disconnect switches shall be mounted on steel channel structures as required.

B. Disconnect switch mounting height shall not exceed 4 feet from the enclosure center line floor.

C. Provide nameplates indicating panel and circuit designation on all disconnect switches. Nameplates shall be phenolic, black face with white core.

3.02 WIRING

A. Connect disconnect switch with wire sizes as indicated on the Drawings.

END OF SECTION 26 28 16

SECTION 26 31 01

PHOTOVOLTAIC SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. This is a performance specification which includes the design and construction of a 92 kW complete Photovoltaic System (PV), including all AC and DC components. The location of the Photovoltaic System shall be the northeast corner of the Eastridge Transit Center parking lot. The design and installation shall conform to all requirements as defined by the applicable codes, laws, rules, regulations and standards as specified herein.

B. The Contractor shall include all items and all work reasonably required to complete the System in accordance with the Agreement. If the Contractor is in doubt as to the intent of any portion of these specifications, or necessary information is omitted, the Contractor shall notify the VTA in writing for clarifications or corrections to be provided by addendum.

C. All design documents, cut sheets, and technical specifications shall be submitted, reviewed and accepted by the VTA per the guidelines specified in the Contract Data Requirements.

1.02 WORK INCLUDED

A. The work shall include the design, engineering, materials, labor, equipment, installation, testing, services, commissioning and incidentals necessary to install a complete Photovoltaic (PV) System in conformity with applicable codes and professionally recognized standards.

B. PV systems shall consist of arrays of framed photovoltaic modules, mounting hardware, terminal boxes, combiner boxes, quick-connect electrical connectors, DC wiring, DC disconnects, utility interactive inverters, AC disconnects, AC feeders, AC circuit breakers, AC panel boards / switchgear, and complete data acquisition and monitoring systems.

C. The PV systems shall be utility grid connected. The Contractor shall be responsible for all required utility company coordination, applications, inspections, permits, and final approval for the complete interconnection of the PV systems with the utility company grid, including bi-directional utility meters at each location.

D. The Contractor is responsible for interconnection and is responsible for all affected electrical system shutdown coordination.

E. The Contractor shall provide full-year modeling for both shading and insolation. The Contractor shall ensure that no shadows are cast on the array at any time of year and that no shade falls on pyranometer.

F. The Contractor shall ensure adequate clearance and equipment space within the allotted areas and building and site conditions. All equipment and sizes / clearances shall be coordinated with the VTA prior to rough-in.

1.03 RELATED DOCUMENTS

A. Division 1 of the Specifications

B. Section 26 05 00: Common Work Results for Electrical Systems Specifications

C. Section 05 90 00: Photovoltaic Mounting

1.04 MEASUREMENT AND PAYMENT

A. Measurement: Photovoltaic System shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Photovoltaic System shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing the Photovoltaic System complete in place, as specified in the Technical Specifications and as directed by the VTA, and no additional compensation will be allowed therefore. The lump sum price paid for the PV System includes the design and construction/installation services for the PV panel system.

1.05 REFERENCES

A. ACI American Concrete Institute

1. ACI-318 Requirements for Structural Concrete

B. AISC American Institute of Steel Construction

C. ASCE American Society of Civil Engineers

1. ASCE-7 Minimum Design Loads for Buildings and Other Structures

D. ASTM American Society of Testing and Materials

E. IEC International Electrotechnical Commission

1. IEC 61727 Photovoltaic (PV) systems – Characteristics of the utility interface
2. IEC 62109 Safety of power converters for use in photovoltaic power systems, both Parts 1 and 2
3. IEC 61215 & 61646 Design qualification and type approval for crystalline silicon and thin-film PV modules
4. IEC 61730 Module Safety Qualification
5. IEC 62093 Balance of System components for photovoltaic systems
6. IEC 61724 Photovoltaic systems performance monitoring – guidelines for measurement, data exchange and analysis
7. IEC 62548 Installation and Safety Requirements for Photovoltaic (PV) Generators

F. IEEE Institute of Electrical and Electronic Engineers, Inc

1. IEEE P929 Recommended Practice for Utility Interface of Photovoltaic (PV) Systems
2. IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems
3. IEEE 519 Recommended Practices and Requirements for Harmonic Control in Electric Power Systems
4. IEEE 1262 Recommended Practice for PV Module Qualification, Performance, and Reliability
5. IEEE 1374 Guide for Terrestrial PV Power System Safety
6. IEEE 2030 Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with Electric Power Systems and End-use Applications and Loads

G. NFPA National Fire Protection Association

H. NIST National Institute of Standards and Testing

1. 800-82 Guide to Industrial Control Systems (ICS) Security Standard

I. NRCA National Roofing Contractors Association

J. NREL National Renewable Energy Laboratory

K. OSHA Occupational Safety and Health Administration

L. SEAC Structural Engineers Association of California

M. Underwriters' Laboratories, Inc. (UL)

1. UL 1741 Inverters, Converters, Controllers, and Interconnect System Equipment for use with Distributed Energy Resources
2. UL 1703 Standard for Safety for Flat Plate Photovoltaic Modules and Panels
3. UL 2703 Rack Mounting Systems and Clamping Devices for Flat Plate Photovoltaic Modules

1.06 SUBMITTALS

A. Refer to Section 26 05 00, 1.06, Submittals.

B. Submit a list of all equipment and materials, layout including single-line electrical diagrams showing utility interconnection and all devices comprising the PV system (PV arrays, combiner boxes, circuit breakers, disconnect switches, inverters, meters, timers, control devices and other equipment comprising the complete system), mounting details for the PV system, elevation drawings showing conduit runs, and product data sheets of all materials intended for use to VTA’s Representative for approval prior to start of work.

C. Contractor shall submit the “as-Built” drawings and specifications as CAD and pdf files. Including start-up, operation and maintenance manuals with spare part lists, control diagrams, schematic and interconnection wiring diagrams of all electrical work, including terminal blocks and identification numbers, wire numbers and wire colors.

D. All low-voltage wiring; communications, metering, and meteorological instruments: and fault detection/alarming systems shall have separate diagrams/drawings.

E. Calculations showing system sizes and annual Kilowatt-hour production. Power capacity (DC kW) as calculated at the inverter input, Power capacity (AC kW) as calculated at the electrical interconnection point, wire loss, inverter loss, and transformer loss.

F. Submit drawings in color showing the array arrangements for future use by maintenance. A copy of this shall be posted in a VTA designated area.

G. Design submittals required

1. In progress (60%): Include design analyses and drawings.
2. Final Design (100%): Include updated design analyses, drawings, and manufacture’s data sheets. Incorporate comments from 60% design submittal that includes a spreadsheet identifying comments and how the comment was addressed in the design.
3. Ready for Construction: Incorporate comments of the Final design and submit original design documents. The Ready for Construction design must include a professional engineer stamp for the construction to proceed.
4. Provide three hard copies and one electronic copy of the design documents at each stage for review. Allow a minimum of 3 weeks for review by VTA.

1.07 PROJECT/SITE CONDITIONS

A. Project/Site Environmental Conditions

1. Refer to Drawings EP702 and EL201 for single line diagram and location of the PV System.
2. Route wire and cable as required for Project conditions.
3. Determine exact routing and lengths of wire required and reflect on the drawings.

1.08 MATERIALS, DELIVERY, STORAGE, AND HANDLING

A. All materials shall be delivered new, undamaged and without defects.

B. All equipment and panels shall be handled with care so as not to damage the delivered products. All equipment shall be installed in new and neat condition.

C. Appropriate protective clothing shall be worn when handling the equipment.

D. All materials stored on site shall follow the guidelines of the system manufacturer including protection boards, pallets and/or mats to prevent damage.

PART 2 - PRODUCTS

2.01 GENERAL

A. All components of the PV System are to be new and of the same manufacturer and product line.

B. All PV hardware and rack components shall be of corrosion-resistant material, such as stainless steel, aluminum or hot dipped galvanized steel.

C. Major electrical components, including the inverter, isolation transformer, and metering, shall be installed in code-compliant enclosures. Components shall be located indoors whenever feasible, in ventilated rooms and where space and code allows. When inverters and major electrical components are located outdoors they shall be protected from direct exposure to weather. Inverters shall not be located on roofs in direct sun.

D. The Contractor shall coordinate with the Engineer regarding locations and appearance of all equipment including PV modules, conduit, inverters, disconnect switches, wireways and control and monitoring equipment.

E. Electrical equipment and components used in PV system shall have markings that identify the manufacturer, size, type, ratings, hazard warnings and other specifications. All labeling shall be designed to withstand the environment in which they are installed and permanently affixed to the respective equipment in a manner appropriate for the environment and compatible with the substrate materials.

F. The electric delivery of the PV system shall be measured by utility-grade metering equipment. The meter shall be a solid state advanced meter with the following features: non-volatile memory capable of storing measured data for 30 days and accuracy meeting ANSI 12.20 0.5% accuracy.

G. Workmanship shall be of a high standard and shall conform in all respects to the best installation practices for solar panels and electrical installations that include clear solar string arrangements and proper wire management.

2.02 MANUFACTURERS

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

2.03 SYSTEM REQUIREMENTS

A. Design and performance requirements for materials, products, and systems must be met as outlined below and included in the development of the design.

1. 92 kW-DC solar PV array (approximate)
2. Micro-inverters or string inverters
3. Revenue grade meter and pyranometer

4. 5-year installer warranty
   a. Warranty of parts and labor
   b. 99% uptime guarantee
5. 25-year manufacturer warranty
6. Online monitoring system
7. Powertrack
8. Parallel-wired system
9. Contractor to design and furnish a Data Acquisition System (DAS) for remote PV monitoring

2.04 MATERIALS

A. Solar Photovoltaic Modules

1. All PV Modules shall meet the following specifications:
   a. Module manufacturer that has produced no less than 250MW of modules in the prior year.
   b. Modules are from a field-tested product line that has been commercially available for no less than three years.
   c. Module manufacturer shall provide a 25-year warranty on the solar modules with at least 80 percent power output guaranteed at 25 years.
   d. Have a minimum 25-year design life, designed for normal, unattended operation.
   e. UL 1703 listed.
   f. UL listed for the specified voltage (typically 1000 V-DC).
   g. Meet IEC 61215 (crystalline silicon PV modules) or IEC 61646 (thin film PV modules) standards.
   h. Project costs shall include all known and future duties, tariffs, export tariffs, customs, demurrage, and shipping costs.
   i. Meet California SB1 Guidelines for Eligibility.

B. Array Mounting Racks

C. Grounding Equipment

1. Shall conform to NFPA 70, IEEE 80, IEEE 142, IEEE 242 and IEEE C2, except that ground rods and grounding systems shall have a resistance to soild earth ground not exceeding 5 Ohms.
2. Provide ground rods made of copper-clad steel conforming to UL 467 with minimum diameter of ¾" and length of 10 feet.
3. Equipment grounding conductors shall be stranded copper, except that sizes No. 10 AWG and smaller shall be solid copper. Insulation color shall be continuous green for all equipment grounding conductors, except that wire sizes No. 4 AWG and larger shall be identified per NFPA 70.
4. Bonding conductors shall be bare stranded copper, except that sizes No. 10 AWG and smaller shall be bare solid copper.
5. Ground connections:
   a. Below grade and inaccessible locations: Exothermic-welded type connectors.
   b. Above grade:

i. Bonding jumpers: compression type for wire sizes No. 8 AWG or larger, mechanical type lugs for wires smaller than No. 8 AWG.

ii. Connection to building steel : Exothermic weld.

D. Combiner Box

1. Combiner boxes (where used) shall be NEMA 3R rated (minimum) and shall include fuses for string inputs and a bus bar to combine the strings into sub-arrays, for input into the Inverter system. Minimum combiner box output bus ampacity shall be 156% of the rated short circuit current available to be carried on the bus (the sum from all strings to the bus).

E. Surge Protection

F. Meters and Instrumentation

1. Provide and install a revenue grade alternating current (AC) Interval Data Recording (IDR) meter, located on the output side of the inverter, complete with industry standard telemetry for communications with Ethernet, cellular or other common output capabilities. Meter must conform to the Owner's and PG&E's metering requirements. If the power is tied into the internal electrical grid, then advanced metering infrastructure (AMI) meters are to be installed.

2. The meter must be UL listed and conform to ANSI C12.1.

3. Provide and connect meter to a power monitoring/data collection system recording solar production through Time of Use (TOU) increments applicable to the installation and utility standards with a minimum of 15 minute intervals and 30 day memory.

G. Inverter

1. All inverters shall meet the following requirements:

a. String-type inverters or microinverter

b. Integrated AC and DC disconnects.

c. Include a 10-year warranty.

d. Manufacturer produced no less than 250 MWp of inverters in the prior fiscal year.

e. Field-tested product line that is commercially available for no less than 2 fiscal years.

f. UL 1741 listed and Comply with IEEE 1547, including testing to IEEE 1547.1 and IEEE C62.45. Regulatory standards compliance shall also include IEEE C62.41.2 and CSA107.1-01.1.

g. Incorporate disconnect switch for main DC power disconnect in compliance with applicable codes and utility requirements.

h. Sized as required to support the PV module production load within the rating of the equipment, together with all other components.

i. CEC approved, Rule 21 compliant and shall be utility line interactive type.

j. Capable of producing reactive power to operate between a power factor of 0.9 lagging to 0.9 leading (as adjusted on the inverter equipment).

k. Meet the following requirements:

i. Nominal AC Voltage (Three-phase, + 10%): 208, 240, or 480 VAC (as required per site)

ii. Nominal AC Frequency (+ 0.5 Hz): 60 Hz

iii. Line Power Factor (Above 20% rated power): >0.99

iv. AC Current Distortion (At rated power): <5% THD

v. Maximum Open Circuit Voltage DC: 1,000 VDC

vi. Maximum Ripple Current (% of rated current): <5%

vii. Minimum Inverter Efficiency: >96%

viii. Temperature Range Ambient: -4º F to 122º F (-20º C to 50º C)

ix. Enclosure Environmental Rating (minimum): NEMA 3R

x. Relative Humidity (non-condensing): 0-95%

xi. Protective Functions: Standard wakeup voltage, wakeup time delay, shutdown power, shutdown time delay, AC over / under voltage and time delays, AC over / under frequency and time delays, ground over current, over-temperature, AC and DC over current, DC over voltage

xii. User Display: Standard-LCD with on/off capability

xiii. DC Disconnect: 1,000 VDC load break rated

xiv. Isolation Transformer (if applicable): High efficiency type, supplied by the manufacturer of the Inverter Systems, mounted within same enclosure or directly adjacent, with factory designated wiring provisions.

xv. Zone 4 Seismic Rating (free standing) or wall mounted

xvi. Internal combiner panel option to allow connections of sub-arrays at the Inverter without the use of additional equipment.

H. Disconnects

I. No substitution for contracted equipment shall be made without the written consent of Institute. Such consent will not to be unreasonably conditioned, delayed, or withheld.

J. Upon connection of the new PV systems, provide a placard on the respective Main Switchboard to identify the two sources of power feeding the equipment.

K. All AC interconnecting feeders shall be sized to NEC Table 310.16 (75 degree column) based on associated disconnect amperage. Conduit fill to 40% max. Include temperature derating as required for the ambient temperatures and roof conditions per NEC. Provide equipment grounding conductor in each conduit.

L. All roof and exterior mounted raceways shall be designed and installed to accommodate expansion and contraction due to heating affects, including adequate cable length and listed expansion couplings. All expansion couplings or installations shall include grounding bonding jumpers as required by code.

M. All AC circuits to be 3-wire or 4-wire + ground. All grounding per NEC 690, Part V.

N. All DC circuits and feeders sized to NEC table 310.16 (90 degree column) based on associated disconnect amperage. Minimum ampacity shall be 156% of the rated short circuit current available to be carried on the specific conductor. Conduit fill to 40% max. Include temperature derating as required for the ambient temperatures and roof conditions per NEC. Provide equipment grounding conductor in each conduit.

O. All DC circuits to be 2-wire + ground.

P. All AC and DC wiring in conduit to be RHW-2, PVWIRE, THWN-2, or XHHW-2 (90 degree) wet rated for use with 90 degree listed terminals on PV equipment.

Q. All exposed DC wiring to be USE-2, PVWIRE, or SE (90 degree) wet rated and sunlight resistant or PV Wire.

R. Above ground exposed conduit shall be rigid galvanized steel with threaded fittings. All conduits shall meet NEC Code, and any applicable standards. Exterior installations shall have watertight fittings. All conduits shall be rated for exposed installation and a minimum design life equivalent to the solar panels.

Paint all visible exposed raceways and boxes to match adjacent surface finish after installation. Colors to be selected and approved by the Owner, such approval not to be unreasonably conditioned, delayed, or withheld.

S. All conduits and stub-ups under array canopies shall be encased within concrete caissons or piers or, protected from parking traffic with appropriately sized bollards if protection is required by electrical engineer.

T. All interior conduits to be EMT with steel set-screw fittings (no cast fittings).

2.05 LIGHTING

A. Canopy lighting systems shall be designed to meet the Illuminating Engineering Society of North America (IESNA) requirements for parking lot areas to meet or exceed minimum values of 1 Foot-candle average and 15 to 1 uniformity ratios as listed in the IESNA criteria.

B. Canopy Lighting shall meet all Title 24 requirements for installations in California.

C. All lighting sources shall be LED type.

D. Lighting control system shall be connected to the existing lighting controls in each area.

E. The routing of all exposed conduit shall be proposed by the contractor and approved by the VTA prior to rough-in.

F. Existing pole mounted lighting in areas of new carport canopies shall be removed. Modify other existing lighting to coordinate with the new work and design, including reconnection of any existing downstream circuiting and controls to remain. Foundations of existing pole mount lighting are to be completely removed a minimum of 6-inchs below grade, with grade restored to surrounding condition.

G. New design shall cover all areas of the parking lots (in the area of the work) to leave no dark spots and meet IESNA and requirements for all areas previously covered by light standards removed under this contract. Contractor shall install new pole mounted luminaires if canopy lighting does not provide sufficient lighting in all areas previously covered by removed or altered light standards. Existing fixtures may remain, if not in direct conflict with canopies or causing shading of new canopies.

H. A lighting plan shall be included showing proposed mounting locations and heights of lightings in relation to the parking lot and surrounding building structure. Lightings shall be mounted to the bottom of the solar structure. Lighting plan shall include proposed routing of conduit and conductors for lightings mounted on the solar canopy, through main structural column and along underside of solar canopy to lightings.

2.06 SECURITY CAMERA

A. Design, furnish, install and test security cameras installed under the canopy structures. This system shall be integrated with the existing CCTV system.

2.07 WIRE MANAGEMENT

A. All inter-array wiring methods must meet or exceed current industry standards for wire management, strain relief and fastening.

B. All inter-array wire management shall use stainless steel or galvanized steel cable clips, Heyco or similar. UV rated cable ties shall be used minimally and only in locations where the use of cable clips are impossible.

C. Where exposed, wires, cables and conductors shall be managed in a neat and orderly manner. Where exposed to environmental conditions e.g. sunlight, rain, wind etc. and visible from below, wires shall be fastened in a uniform and discrete fashion and shall be rated for such exposure.

D. All conductors and conduits between separate arrays shall be routed underground. Wiring shall be routed down columns, encased in piers/caissons, routed underground between arrays or carports, and up the nearest column on the adjacent array. Under no circumstance will circuits, conduits, or chaseways be mounted overhead between separate structures, including seismic gaps).

E. Strain relief and drip loops shall be utilized at all entrances to and from conduit bodies, junction boxes, weather heads, switchgear, inverters and panelboards etc. Conductors shall be strapped with strain relief as not to stress panel leads, home runs or mechanically crimped connections within the array.

F. DC cables running from separate arrays shall be clearly identified and managed.

G. Wires will be hidden from view from below. Use wire gutters matching the panel installation.

H. Wire management to be approved by VTA.

2.08 MISCELLANEOUS SYSTEM REQUIREMENTS

A. All exterior equipment to be sunlight and UV resistant as well as rated for elevated temperatures at which they are expected to operate (on roofs in hot sunlight).

B. No dissimilar metals are allowed to contact each other (use plastic or rubber washers) with the exception of anodized aluminum module frames in contact with galvanized carport purlins. Best practices shall be used to avoid corrosion.

C. No aluminum in contact with concrete or masonry materials.

D. Bolted connections shall be non-corrosive and include locking devices designed to prevent twisting over the design life of the PV system.

E. Environmental impact of system equipment containing hazardous materials shall be disclosed, as well as maintenance and disposal instructions for equipment at the end of its useful life.

2.09 SYSTEM ELECTRICAL

A. The modules shall be interconnected using cable assemblies. The pigtails shall be quick-connect electrical wiring connections rated for the application (90 degree rated).

B. Raceway system shall be installed in a manner that prevents water from draining into electrical equipment.

C. Full specifications of the inverter shall be supplied as part of the system submittal.

D. All major components of the systems and the installation procedures shall meet National Electrical Code requirements, including Article 690.

E. The PV system shall be designed to automatically drop offline when normal utility power is lost to avoid unintentional islanding effects as required by the local utility.

F. All electrical system equipment shall be properly rated to withstand and interrupt (in the case of over current protection devices) the available fault current at the point of use.

G. The system shall be capable of producing reactive power to operate between a power factor of 0.9 lagging to 0.9 leading (as adjusted on the inverter equipment).

H. All required overcurrent protection and electrical bussing sizes per NEC 690.

I. Means of system grounding to be approved by professional Electrical Engineer of record and GFCI protection shall be in accordance with latest NEC requirements.

J. Engineer shall perform breaker setting coordination study for all breakers installed.

K. Provide arc-flash warning labeling, including a description of the Personnel Protective Equipment (PPE) required for maintenance worker protection at electrical enclosures.

2.10 MONITORING

A. A Data Acquisition and Monitoring System (DAS) shall be provided for all points of interconnect. The system shall include, but not be limited to, the measurement, calculation, display, and reporting of the following items:

1. PV production in 15-min reporting intervals.
2. Energy consumption in 15-min reporting intervals.
3. Weather data in 15-min reporting intervals
4. System electrical functions (instantaneous and accumulated power output (kW and kWh), AC and DC system voltage and amperage, and peak value tracking with associated time stamps)
5. Pounds of CO_2 emissions avoided from the generation of PV energy at the site (compared to local utility fuel mix electric carbon content)
6. Generation data in the Western Renewable Energy Generation Information System (WREGIS) format
7. Lifetime access to data reported by DAS
8. DAS shall allow customer or customer's third party designee to programmatically download data through Application Program Interface ("API"). This data shall, at a minimum, include PV production data, energy consumption data, weather station and/or satellite data, and alarm status readings. All data shall be available over multiple timescales, ranging from 15- min intervals to annual intervals and shall include both real-time and historic data.
9. Power track by Also Energy.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Site Verification of Conditions

1. Verify that any work likely to damage PV system has been completed.

3.02 INSTALLATION

A. The Contractor shall furnish and install a complete photovoltaic carport structure, with the photovoltaic array complete and operational in grid-connected operation.

B. The shade structure shall have a roof deck that will support the PV array and shall control the fall of water onto vehicles and occupants.

C. For double-wide rows, carports shall be designed to be supported by central support posts and cantilever over parking spaces on both sides, like a "T." For a row at the edge of the parking lot, carports shall be designed to be supported by a braced post and cantilever over the parking space, like a "7."

D. The PV panels on the carport shall be sloped to balance aesthetics and power production. The carport PV shall be at least 12 feet clear in all locations.

E. All light-gauge, cold-formed structural members and panels shall be designed in accordance with the latest version, with addendums, of the American Iron and Steel Institute (AISI) "Specification for the Design of Cold-Formed Steel Structural Members."

F. Welding of the light-gauge, cold-formed structural members shall be in accordance with the latest version of the "Structural Welding Code - Sheet Steel" (AISC/AWS Dl.3). All structural steel sections shall be designed in accordance with the latest version, with addendums, of the AISC "Specifications for the Design, Fabrication and Erection of the Structural Steel for Buildings."

G. The steel roof panel shall be coated steel conforming to ASTM A792, ASTM A653, or ASTM A611, with a minimum yield strength of 80 kilopounds per square inch (ksi) or equal. The roof panels shall be factory pre-painted.

H. Light-gauge steel beams and columns shall conform to ASTM A653, with minimum yield strength of 55 ksi.

I. Concrete shall be done in accordance with the latest edition of ACI 318 "Specifications for Structural Concrete for Buildings," and shall be 2,500 pounds per square inch (psi) at 28 days. Reinforcing shall be new billet steel conforming to ASTM A615, grade 40.

J. All steel framing fabrication shall be done by an approved fabricator and certified by an independent agency, for the type of fabrication required. Certification shall be as required by the local municipality.

K. Welders holding a valid certification for the type of welding required shall perform all steel welding. Certification shall be as required by the local jurisdiction.

L. Contractor is responsible for locating all existing underground utilities prior to excavation and for utilizing the "Call Before You Dig – http://call811.com" hotline to confirm with any potentially affected public utility company locations of underground utilities. Any damage done to existing underground utility systems are the sole responsibility of the Contractor.

M. All ground-mounted electrical supporting equipment (inverters, transformers, and switchgear) shall be installed on concrete slab(s) with appropriately sized and spaced rebar. The sizes and strength of the pad and rebar shall be adequately calculated and designed by the contractor.

3.03 NAMEPLATES

A. All nameplates shall be machine generated phenolic type with red background and white lettering, affixed to equipment with stainless steel screws or with permanent adhesive where set screws are not feasible. Minimum lettering size to be 1/4" unless otherwise noted or required for legibility.

B. Provide a nameplate clearly visible at main service panel to identify both sources of power, with the following wording in 1/4" high lettering per NEC 690.64(B)(4): "Warning - This Service Is Fed By Two Sources Of Power – The Utility Service Main Disconnect And The PV System Main Disconnect – Both Services Must Be Disconnected To Remove Power From The Switchboard".

C. Provide a nameplate on PV system input circuit breaker (where used) at the main panel with the following wording in 1/4" high lettering per NEC 690.64(B)(7): "Warning – Inverter Output Connection – Do Not Relocate This Overcurrent Device".

D. Provide a nameplate on all disconnects with the following wording in 1/4" high lettering per NEC 690.17: "Warning - Electric Shock Hazard - Do Not Touch Terminals - Terminals On Both The Line and Load Sides May Be Energized In The Open Position".

E. Provide a nameplate on the Main PV System Disconnect (adjacent to each main service panel) with the following information in 1/4" high lettering per NEC 690.53: "Photovoltaic Power Source Disconnect - Operating Current: X Amps; Operating voltage: XX VAC; Maximum System Voltage: XX VAC; Short-Circuit Current: XXX Amps", where X is the operating current, XX is the system voltage, and XXX is the maximum short circuit current contribution of the generating facility at the point of interconnection with the utility system.

F. Provide a nameplate at Main Switchboard with the following information in 1/4" High lettering per NEC 690.54: "Caution - Possible Backfeed From Photovoltaic Power System – X VAC, XX Amps", where X is the system voltage and XX is the maximum AC amperes of the installed system.

G. Provide a nameplate on PV System Inverter with the following information in 1/4" high lettering: "Photovoltaic Power Source Inverter Rating - Operating Current: XX Amps; Operating voltage: XXX VDC; Maximum System Voltage: 1,000 VDC; Short-Circuit Current: XXXX Amps", where XX is the maximum DC amperes of the installed system, XXX is the operating voltage DC, and XXXX is the short circuit current that the Inverter can provide (from all strings in parallel).

H. Provide utility-required System Directory and utility safety switch Identification nameplate as required by local utility company, to identify all system components.

I. Provide a nameplate for all Combiner Boxes to read: "DC Combiner Box [XXX] – [System Voltage] VDC Maximum".

3.04 SYSTEM STARTUP AND COMMISSIONING

A. The contractor shall provide all work required for testing, start-up, and commissioning as required by the following requirements.

1. Commissioning standard IEC 62446 shall be followed, and associated reports shall be included with the submittal package.
2. The Contractor shall provide the services of the manufacturer's certified technician to perform start-up and acceptance testing of the PV System.
3. The Engineer may request to be present during any or all phases of the start-up and testing activities.
4. Complete a system commissioning per the Specification and equipment manufacturer's written instructions.
5. Request and coordinate with Utility for acceptance and certification of the PV system and permission to operate.
6. Set and adjust circuit protection devices according to the Short Circuit and Coordination Study.

3.05 ACCEPTANCE TESTING

A. The Contractor shall conduct inspection and testing of each of the PV systems in accordance with its own quality-control plan and the following:

1. Manufacturer recommendations.
2. IEC 62446, Grid Connected Photovoltaic Systems Minimum Requirements for System Documentation, Commissioning Tests and Inspection.
3. The International Code Council (www.ICCsafe.org) Acceptance Criteria 286 for Roof Flashing for Pipe Penetrations and Acceptance Criteria 428 for Module Framing Systems Used to Support PV Modules.

B. The Contractor shall provide visual inspection, array testing, and whole –systems testing as specified in IES 62446.

C. The Contractor shall notify the Engineer not less than five (5) Business Days prior to the anticipated date of PV System Acceptance Testing. The VTA shall have the right, but not the obligation, to be present at and observe the System Acceptance Testing.

D. A NETA certified independent testing agency shall be engaged to perform testing of the newly installed PV system.

E. Acceptance shall be after the PV system has generated electric energy for ten (10) continuous days at energy and power production levels consistent with the proposed PV system's estimated production with 100% system availability, measured with applicable instruments and meters; the PV system has been commissioned per IEC 62446 and approved for interconnected operation. At that time, the Contractor shall send a Completion Notice and a copy of the System Acceptance Testing to the Engineer so that the final inspection can be completed.

F. The warranty holder or a roofing contractor certified by the roof manufacturer shall inspect the roof after installation to ensure roof integrity and compliance with the International Code Council (www.ICCsafe.org) Acceptance Criteria 286 for Roof Flashing for Pipe Penetrations and Acceptance Criteria 428 for Module Framing Systems Used to Support PV Modules. The Contractor shall comply with all Section C requirements, and an inspection by a licensed electrical inspector is mandatory after construction is complete.

G. Some commissioning activities may commence before the system is operational. After the electrical commissioning agent gives permission for either interim testing for operation in parallel with the electrical utility system is granted, the Contractor shall complete commissioning and acceptance testing of the PV system, in accordance with its own quality-control plan, manufacturer recommendations, utility interconnection requirements, and IEC 62446 Grid Connected Photovoltaic Systems Minimum Requirements for System Documentation, Commissioning Tests and Inspection.

H. If any of these requirements are not met, then the Engineer shall provide Contractor with a detailed notice of such failure (a “Rejection Notice”) within the ten (10) Business Day period, and Contractor shall promptly remedy at Contractor’s cost the relevant, specified failure and conduct new System Acceptance Testing until it indicates that the PV systems meets the requirements. In each such case, the Contractor shall send a new Completion Notice to the Engineer with a copy of the results of the new System Acceptance Testing as provided above, and the foregoing procedures shall be repeated.

END OF SECTION 26 31 01

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SECTION 26 33 33

EMERGENCY LIGHTING POWER SUPPLY

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes requirements for an off-line compact AC power system for emergency operation of LED lighting that provides full light output for 90 minutes of operation.

1.02 REFERENCED STANDARDS

A. ANSI/NFPA 70 - National Electrical Code

B. FCC rules and regulations of Part 15, Subpart J, Class A

C. IEEE 587/ANSI C62.41 – Standards for Surge Withstand Ability

D. UL 924 – Standards for Emergency Lighting and Power Equipment

1.03 SUBMITTALS

A. Refer to Section 26 05 00, 1.06 Submittals.

B. Submit a list of all equipment and materials, and product data sheets of all materials intended for use to Engineer for approval prior to start of work. Submit shop drawings to show physical arrangements, connections, finishes, provisions for connections, access requirements for installation and maintenance, physical size, electrical characteristics and ratings, foundation and support details, and equipment weights, where such details are not indicated on the catalogue cuts.

C. Detailed test procedures for each test, a minimum of 15 days prior to the date of scheduled testing.

D. Retain all manufacturer documentation including maintenance and warranty information accompanying the installed equipment and materials. Documentation and warranty information shall be submitted to the Engineer upon request, but not later than the date when the installation is complete.

1.04 QUALITY ASSURANCE

A. Refer to Section 26 05 00, Quality Assurance.

1.05 DELIVERY, STORAGE, HANDLING

A. Refer to Section 26 05 00, Delivery, Storage and Handling

1.06 WARRANTY

A. Refer to Section 26 05 00, 1.12 Warranty.

1.07 MEASUREMENT AND PAYMENT

A. Full compensation for work under this section shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Myers Power Products Inc., or approved equal

B. Acuity Brands Power Sentry or approved equal

2.02 EMERGENCY LIGHTING POWER SUPPLY

A. Features a solid state, pulse width modulated inverter, utilizing IGBT technology. Offline uninterruptible system has 2-millisecond transfer time. Free-standing NEMA Type 1, 16-guage steel cabinet with hinged lockable doors.

B. Sinusoidal output waveform has <3% maximum Total Harmonic Distortion for linear load. Operating efficiency is 97% at full load.

C. Input: 120 or 277 V

D. Output: 120 or 277 V

E. Microprocessor controlled charger for lead-calcium battery type and temperature compensating per UL924 spec.

F. Programmable self-diagnostic testing for 5 minutes monthly.

G. Microprocessor controlled 2X20 character display with touch pad controls, functions and data logging.

H. LCD meter panel displays input voltage, output voltage, battery voltage, battery current, output current, output VA, temperature, date, time and inverter wattage. Five LED indicators display utility present, battery power, battery charging, system ready, and fault.

I. Alarm functions: one audible alarm will indicate high/low battery charger fault, near low battery, low battery, load reduction fault, output overload, high/low AC input volts, high ambient temperature, inverter fault, output fault.

J. Batteries shall be maintenance-free, sealed lead-calcium batteries. Ambient operating temperatures are 32 to 100 degrees F.

K. Discharge cycle of 90 minutes with fully charged batteries.

L. UL listed and meets UL924, NFPA 101, NFPA 70, NEC and OSHA.

M. The emergency lighting inverter shall be rated 2250 VA at Story Station and 3000 VA at Eastridge Station at 277V and be Acuity Brands Power Sentry with at least 8 output breakers or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Maintain minimum working clearance at equipment according to manufacturer’s written instructions.

B. Install interconnections between system components. Make connections to supply and load circuits according to manufacturer’s wiring diagrams, unless noted otherwise on the Drawings.

C. Identify each battery cell individually.

D. On completion of installation, inspect system components. Remove paint splatters, other spots, dirt and debris. Repair scratches and mars to match original finish. Clean components internally using methods and materials recommended by the manufacturer.

3.02 FIELD TESTING AND COMMISSIONING

A. Site Support, Inspection and Testing: Technical Representative shall test the equipment in accordance with an approved site test procedure. Tests shall be made in the presence the Engineer. The application or interruption of power shall be programmed and directed in accordance with the approved Equipment Energization Plan and necessary permits, work tasks and safety compliance steps.

B. The Contractor shall submit to the Engineer test results, certified in writing, witnessed, signed and dated, immediately upon completion of work for review and acceptance by the Engineer. An unsatisfactory condition revealed by these test results, or unsatisfactory methods of tests and/or testing apparatus and instruments, shall be bought to the attention of the Engineer. Corrections by the Contractor shall be validated by re-tests to the satisfaction of the Engineer.

C. The Engineer reserves the right to require that the Contractor perform and repeat tests that are deemed necessary to complete or check the tests or the certified records of the Contractor at any time during the course of the work. The Contractor shall correct unsatisfactory portion of his work that is revealed by the tests or that may be due to progressive deterioration during this period, unless the item in question was a direct specification.

D. The Contractor shall pretest system functions, operations and protective devices and perform tests listed below. Use instruments that have been calibrated according to NIST standards within six (6) months previous to field testing.

1. Load the system using a variable load bank simulating kVA, kW and power factor of loads for which the unit is rated.
2. Simulate malfunctions to verify protective device operation.
3. Test duration of supply on emergency, low battery voltage shutdown and transfers and restoration due to normal source failure.
4. Test harmonic content of input and output current less than 25, 50 and 100 percent of rated loads.
5. Test output voltage under specified transient load conditions.
6. Test remote status and alarm panel functions.
7. Test battery monitoring system functions.

E. Correct deficiencies and retest until specified requirements are met.

F. Equalize charging of battery cells according to manufacturer’s written instructions. Record individual cell voltages.

3.03 ACCEPTANCE AND ENERGIZATION

A. Final acceptance shall depend upon the satisfactory test results as performed in accordance with the manufacturer’s instructions. After tests have been reviewed and approved by the Engineer, energization may proceed.

3.04 DEMONSTRATION AND TRAINING

A. An authorized representative shall train Owner’s personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing and preventative maintenance. Schedule training with the Engineer with at least seven (7) days written notice.

END OF SECTION 26 33 33

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SECTION 26 41 23.16

DC SURGE ARRESTERS

PART 1 – GENERAL

1.01 SUMMARY

A. This Section includes requirements for Surge Arresters and related accessories for the Overhead Contact System (OCS), as shown on the Plans and specified herein.

B. Contractor shall prepare detailed designs for each of the required assemblies, based on the basic dimensions specified on the Plans. Contractor's designs for the assemblies shall be subject to acceptance by VTA.

C. Installation of surge arrestors, and their connection to ground, are specified under Section 26 05 26, "Grounding and Bonding for Electrical Systems" and Section 34 23 53, "Overhead Contact System Installation," of these technical specifications.

1.02 SUBMITTALS

A. The following submittals shall be made before fabrication:

1. Complete manufacturer's description, catalog data, and information including model number.

2. Surge arrester test data technical parameters including the effects of increase in ambient temperature on leakage current.

3. Manufacturer's general detail and arrangement drawings, and installation instructions.

4. Schematic wiring and interconnection diagrams.

5. Operation and maintenance manual, with list of spare parts.

1.03 QUALITY CONTROL

A. Contractor shall perform the following:

1. Material qualification testing and certification for acceptance of materials, components and assemblies.

2. Job control testing for in-progress work being performed in shops, factories and on-site.

3. On-site inspection of specified work elements.

1.04 MEASUREMENT AND PAYMENT

A. Measurement: DC Surge Arresters shall be measured by each unit (EA).

B. Payment: The contract price paid per each unit (EA) for DC Surge Arresters shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all Work involved in constructing DC Surge Arresters complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by the VTA.

PART 2 – PRODUCTS

2.01 SURGE ARRESTERS

A. Surge arresters shall be outdoor style and of the metal oxide varistor type, and shall be designed for protection of DC systems.

B. The surge arrester shall be designed for MCOV in the 950 V (dc) to 1150 V (dc) range, and shall have an energy discharge capability of at least 2.2 kJ/kV for test currents of 300A or less.

C. The surge arrester shall have a leakage current not to exceed 0.5 mA at MCOV and 1.0 mA for voltages up to 10% over MCOV.

D. Surge arrester shall be able to withstand system temporary over voltages including the effect of train regeneration without any evidence of premature failures.

E. Contractor shall submit the surge arrester test data and technical parameters including the effect of increase in ambient temperature on leakage current and discharge (clamping) voltage.

F. Each surge arrester shall incorporate an individual grounding system which may be connected to a ground rod or ground mat by means of #4 AWG flex copper conductor, insulated, 2kV rated.

G. Refer to Section 26 05 26, “Grounding and Bonding for Electrical Systems,” for general requirements on grounding connections.

PART 3 – EXECUTION

3.01 INSTALLATION REQUIREMENTS

A. The surge arrester shall be connected on OCS pole-feeder and grounding system as shown on the Contract Plans.

B. Surge Arrester installation is covered in Section 26 05 26 “Grounding and Bonding for Electrical Systems” and Section 34 23 53, “Overhead Contact Systems Installation.”

END OF SECTION 26 41 23.16

SECTION 26 42 00

STRAY CURRENT MONITORING

PART 1 - GENERAL

1.1 THIS SECTION INCLUDES

A. The WORK of this Section includes providing a complete Stray Current Monitoring System for the following structures as outlined in this Section and on the Drawings:

1. Capitol Aerial Guideway from ABUT 1 at Station 972+09.89 to ABUT 76 at Station 1079+98.12.

B. Electrical isolation of the rails from the reinforced concrete aerial guideway and electrical cross-bonding of the rails as specified per Division 34, Transportation.

C. Electrical isolation of the top layer of reinforcing steel beneath the rails from the rest of the reinforced concrete aerial guideway and the rails.

D. Electrical bonding of the top layer of reinforcing steel beneath the rails. Electrical bonding across hinges shall be done through a junction box.

E. Installation of test stations, including junction boxes, reference electrode bar, test leads, conduit, other components associated with the Stray Current Monitoring System, and all other work described herein and on the Drawings.

F. Testing of Stray Current Monitoring System after installation.

1.2 REQUIREMENTS

A. If the products installed as part of this Section are found to be defective or damaged or if the WORK of this Section is not in conformance with these Specifications, then the products and WORK shall be corrected at the CONTRACTOR’s expense.

B. Any retesting required due to inadequate installation or defective materials shall be paid for by the CONTRACTOR at no additional cost to VTA.

C. The WORK also requires that one Supplier or Subcontractor accept responsibility for the WORK, as indicated, but without altering or modifying the CONTRACTOR's responsibilities under the Contract Documents.

D. The WORK also requires coordination of assembly, installation, and testing between the General Contractor and any stray current monitoring material supplier or subcontractor.

E. All electrical WORK shall be in accordance with NEC and local requirements.

1.3 RELATED SECTIONS

A. The WORK of the following Sections applies to the WORK of this Section. Other Sections of the Specifications, not referenced below, shall also apply to the extent required for proper performance of this WORK.

1. Section 01 12 16, Work Sequence and Constraints
2. Section 01 78 43, Project Record Documents
3. Section 03 20 00, Concrete Reinforcing
4. Section 03 30 00, Cast-in-Place Concrete
5. Section 34 11 40, Track-to-Earth Resistance
6. Section 34 42 24, Rail Bonding

1.4 REFERENCED STANDARDS

A. The WORK of this Section shall comply with the current editions of the codes and standards referenced in this specification, including the following:

1. ASTM — ASTM International
   a. A123 — Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
   b. A615 — Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
   c. B3 — Standard Specification for Soft or Annealed Copper Wire
   d. B8 — Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
   e. B187 — Standard Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar, and Shapes
   f. D1000 — Standard Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications
   g. D1248 — Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
   h. D1785 — Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
2. NACE International, the Corrosion Society
   a. SP0169 — Control of External Corrosion on Underground or Submerged Metallic Piping Systems
   b. SP0286 — Electrical Insulation of Cathodically Protected Pipelines
   c. TM0497 — Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems
3. NEMA — National Electrical Manufacturers Association

a. 250 Enclosures for Electrical Equipment (1,000 Volts Maximum)

b. TC2 Electrical Polyvinyl Chloride (PVC) Tubing and Conduit

c. TC3 PVC Fittings for Use with Rigid PVC Conduit and Tubing

4. NFPA National Fire Protection Association

a. NFPA 70 National Electric Code (NEC)

5. SSPC The Society for Protective Coatings

a. SP11 Bare Metal Power Tool Cleaning

6. UL Underwriters Laboratories

a. 6 Rigid Metal Conduits

b. 467 Grounding and Bonding Equipment

c. 514B Fittings for Cable and Conduit

B. Whenever the Drawings or these Specifications require a higher degree of workmanship or better quality of material than indicated in the above codes and standards, these Drawings and Specifications shall prevail.

1.5 QUALITY ASSURANCE

A. The Contractor shall perform the WORK of this Section in strict accordance with the requirements of the Contractor's Quality Assurance Plan as approved by VTA as indicated in GC-47, “Quality Assurance Program.”

B. Installation of the stray current monitoring equipment shall be performed by individuals having at least five years of experience in the installation of the stray current monitoring equipment described herein.

C. The Contractor shall perform the following, at minimum:

1. Material qualification testing and certification for acceptance of materials, components, and assemblies.

2. Job control testing of in-progress work being performed in shops, factories, and onsite.

3. Onsite inspection of specified work elements.

D. All testing required to be performed by a “Corrosion Technician” shall be performed by a NACE certified Corrosion Technician under the supervision of a Corrosion Engineer. A Corrosion Technician is a NACE CP2 (CP Technician), CP3 (CP Technologist), or CP4 (CP Specialist). A Corrosion Engineer is a Registered Professional Corrosion Engineer or a NACE CP4 (CP Specialist).

1.6 SUBMITTALS

A. The following shall be submitted to the ENGINEER prior to any equipment installation.

1. A copy of this specification section, with addenda updates, with each paragraph check marked to show specification compliance or marked to show deviations.

2. Catalog cuts, bulletins, brochures, or data sheets for all materials specified herein.

3. Statement that the equipment and materials proposed meet the Specifications and the intent of the Specifications.

4. Statement of installation experience required.

5. Identity and qualifications of the testing service organization shall be submitted in accordance with Section GC-48, "Inspection.”

6. Detailed test procedures for each test a minimum of 45 days prior to the date of scheduled testing.

B. The following shall be submitted to the ENGINEER after completion of the WORK.

1. System Testing Report.

2. Record Drawings shall be submitted to and approved by VTA before the WORK is considered complete.

1.7 INTERFERENCE AND EXACT LOCATIONS

A. The locations of stray current monitoring equipment, test stations, and appurtenances, as indicated, are approximate only. Exact locations shall be determined by the CONTRACTOR in the field subject to the approval of VTA.

B. The CONTRACTOR shall field verify all data and final locations of work done under other Sections of the Specifications required for placing of the electrical work.

C. In case of interference with other work or erroneous locations with respect to equipment or structures, the CONTRACTOR shall furnish all labor and materials necessary to complete the WORK in an acceptable manner to VTA. Deviations from the Drawings and Specifications shall be submitted to the VTA for approval.

1.8 MEASUREMENT AND PAYMENT

A. The contract lump sum price paid for Stray Current Monitoring System shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all the work involved in Stray Current Monitoring System, complete in place, including installing, testing, and retesting system as shown on the Plans, as specified in these technical specifications and as directed by VTA.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials installed must be new. All equipment and materials supplied shall be similar to that which has been in satisfactory service for at least 5 years.

B. Provide equipment and tools necessary to conduct testing in accordance with the approved test procedures.

C. Meters, gauges, and other measuring equipment shall be calibrated within 12 months of the date of each test. Recalibrate equipment on a regular basis during the life of this Contract to continuously meet this requirement.

D. To the degree feasible, use the same testing equipment and test personnel for similar tests during the life of this Contract.

2.2 JUNCTION BOXES

A. Junction boxes shall be NEMA 250 Type 4X enclosure and sized as shown on the Drawings.

B. Junction boxes shall be made of 304 or 316 stainless steel.

C. Junction boxes shall have a single door with a full length hinge and a lockable latch. Hinge, latch, and other miscellaneous metallic components on the cabinet shall be 304 or 316 stainless steel.

D. Junction boxes shall be equipped with permanent identification tags affixed to the outside front door. The identification tag shall have white engraving for the identification of the junction box. Minimum height of lettering shall be 3/4 inch.

1. The tags shall have the following legend for Hinge Bonding Test Station:

VTA

STATION NUMBER

HINGE BONDING JUNCTION BOX

2. The tags shall have the following legend for Corrosion Monitoring Test Station:

VTA

STATION NUMBER

CORROSION MONITORING JUNCTION BOX

2.3 REINFORCING STEEL

A. Reinforcing steel shall be in accordance with ASTM A615 and the Specification section for reinforcing steel.

2.4 TERMINAL BOARDS

A. Terminal boards shall be made of 1/4-inch thick phenolic plastic and sized as indicated on the Drawings.

B. The terminal board shall be labeled with a black plastic tag attached to the front of the board, as shown on the Drawings. This tag shall be engraved in a contrasting color.

C. The connection hardware shall be nickel-plated brass or bronze. All connections shall be double nutted bolts with serrated lock washers.

D. All wires shall be terminated with copper ring terminals to be landed on the terminal board with the connection hardware.

E. Copper bus bar shall be 1/8-inch thick, 1/2-inch wide, and sized to fit. The copper bus bar shall be per ASTM B187 with 98% conductivity.

2.5 SHUNTS

A. Shunts shall be selected by the size indicated on the Drawings.

B. 0.001-ohm, 25-amp shunts shall be Type SS, as manufactured by Holloway, or an approved equivalent.

2.6 VENT DRAIN

A. The vent drain shall allow accumulated water to drain out the bottom of a junction box while maintaining the enclosure's UL and NEMA ratings. It shall use gravity to remove collected liquids via a one-way mechanical shut-off. The vent drain shall either be 304 stainless steel or polyester. The vent drain shall be a H2OMIT Vent Drain as manufactured by Pentair or an approved equivalent.

2.7 CONDUIT AND FITTINGS

A. The minimum conduit size shall be 1 inch unless otherwise indicated. Refer to NFPA 70 (NEC) for additional conduit size requirements.

B. Conduit and fittings embedded in concrete shall be Schedule 80 PVC in accordance with NEMA TC2 and NEMA TC3.

C. Conduit exposed to the atmosphere shall be flexible conduit. Flexible conduit shall be liquid-tight, sunlight resistant, metal conduit with temperature rating from −40 to 105°C or better. It shall be manufactured with a spiral wound strip of heavy gauge, corrosion-resistant, hot-dipped galvanized steel with a rugged, flame retardant, flexible PVC jacket extruded on top. It shall conform to NFPA 70 Article 350 and be listed to UL 360. The flexible conduit shall be Titan 2 Type HC Liquidtight Flexible Metal Conduit as manufactured by Southwire or an approved equivalent.

D. Conduit clamps shall be galvanized steel, 304 stainless steel, or 316 stainless steel.

E. Fittings for use with rigid steel conduit shall be galvanized cast ferrous metal, with gasketed covers, Crouse Hinds Condulets, Appleton Unilets, or an approved equivalent. Rigid metallic conduit fittings shall be galvanized, conform to NEMA FB 1, and listed to UL 514B.

F. Union couplings for conduit shall be Erickson or Appleton Type EC, 0-Z Gedney 3-piece Series 4, or an approved equivalent.

2.8 WIRES

A. Conductors shall consist of stranded copper of the gauge indicated on the Drawings. Wire sizes shall be based on American Wire Gauge (AWG). Copper wire shall be in conformance with ASTM B3 and ASTM B8.

B. Insulation Type and Colors: As shown on the Drawings.

1. High molecular weight polyethylene (HMWPE) wires shall be rated for 600 volts and shall conform to ASTM D1248, Type 1, Class C, Grade 5.

2.9 WIRE IDENTIFICATION TAGS

A. Wire identification tags shall be the wrap-around type with a high resistance to oils, solvents, and mild acids. Wrap-around markers shall fully encircle the wire with imprinted alphanumeric characters for pipe identification. The letters and numbers height shall be 3/16 inch at minimum.

2.10 EXOTHERMIC WELDS

A. Exothermic welds shall be in accordance with the manufacturer's recommendations. Exothermic welds shall be Cadweld manufactured by Erico, Thermoweld manufactured by Continental Industries, or an approved equivalent.

B. Prevent molten weld metal from leaking out of the mold, where necessary, by using Duxseal packing manufactured by Johns-Manville, Thermoweld packing material manufactured by Burndy, Cadweld T403 Mold Sealer manufactured by Erico, or an approved equivalent.

C. The shape and charge of the exothermic weld shall be chosen based on the following parameters:

1. Reinforcing steel material
2. Reinforcing steel size
3. Wire size and requirement for sleeves
4. Number of wires to be welded
5. Orientation of weld (vertical or horizontal)

2.11 EXOTHERMIC WELD COATING

A. After exothermic welding, repair coatings on reinforcing steel, if present, in accordance with the coating manufacturer's recommendation.

B. Coating material for exothermic weld connections to the reinforcing steel shall be two-part ProPoxy 20 epoxy putty manufactured by the Hercules Chemical Company, Repair Putty Multi-Purpose by Loctite, or an approved equivalent. The epoxy putty shall be non-conductive and have at least 300 volts per mil of dielectric strength.

C. Exothermic weld coating shall be cured before concrete is poured around it.

2.12 REFERENCE ELECTRODE BAR

A. The reference electrode bar shall be the same material type as the top layer of reinforcing steel beneath the rails. The reference electrode bar shall be 35 inches long, size #6, and uncoated.

B. The reference electrode bar shall have a wire which will extend to the Aerial Guideway Corrosion Monitoring Junction Box, without splicing, as indicated on the Drawings.

PART 3 - EXECUTION

3.1 MATERIAL AND EQUIPMENT STORAGE

A. Ship each unit securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.

B. All materials and equipment to be used in construction shall be stored in such a manner to be protected from detrimental effects from the elements. If warehouse storage cannot be provided, materials and equipment shall be stacked well above ground level and protected from the elements with plastic sheeting or another method, as appropriate.

3.2 ELECTRICAL BONDING OF REINFORCING STEEL

A. Weld the top layer of reinforcing steel per the Drawings to make the reinforcing steel electrically continuous along the longitudinal length, except at hinges, where the electrical bonding shall occur through bond wires routed through the Hinge Bonding Test Station.

B. At Hinge Bonding Test Stations, bonding wires shall be of the type, size, length, and number shown on the Drawings and installed as indicated. Bonding wires shall allow at least 2 inches of movement at each hinge. The wire shall be attached to the top layer of reinforcing steel by exothermic welding. At least 2 bond wires shall be provided on each side of each hinge.

C. The top layer of reinforcing steel beneath the rails shall be electrically isolated from the rest of the reinforced concrete aerial guideway and the rails.

3.3 REFERENCE ELECTRODE BAR

A. The reference electrode bar shall be electrically isolated from the reinforcing steel in the aerial guideway, including the top layer. Install heat shrink tubing on the reference electrode bar where it crosses the guideway’s reinforcing steel, as shown on the Drawings.

B. The reference electrode bar lead wire shall be terminated on the terminal board, as shown on the Drawings.

3.4 TEST STATIONS

A. Test stations shall be installed at the approximate locations shown on the Drawings. The CONTRACTOR shall field verify all final locations, subject to acceptance by VTA.

B. For Hinge Bonding Test Stations, mount the junction box to the handrail and position conduit as shown on the Drawings before pouring the concrete deck. Dome concrete slightly on the outer radius of conduits to prevent water ponding.

C. For Corrosion Monitoring Test Station, position the conduit as shown on the Drawings before pouring concrete bent. Mount the junction box to the bent as shown on the Drawings after the concrete has cured. Install a vent drain in the bottom of the junction box.

D. Connect wires, shunts, and bus bars to the terminal board as shown on the Drawings. Each wire shall be identified with a permanent wire identifier within 4 inches of the termination. After installation, all wire connections in the test station shall be tested by the Contractor to ensure they meet the requirements herein.

E. The CONTRACTOR shall provide global positioning system (GPS) coordinates for each test station location with a minimum accuracy of 1 meter or 3 feet. The CONTRACTOR shall submit the GPS coordinates of the test stations to VTA after installation.

3.5 WIRES

A. Wires shall be run inside conduit as shown on the Drawings. Each wire run shall be continuous in length and free of joints or splices, unless otherwise indicated. Care shall be taken during installation to avoid punctures, cuts, or other damage to the wire insulation. Damage to insulation shall require replacement of the entire length of wire at the CONTRACTOR’s expense.

B. At least 2 inches of slack shall be left for each wire at each test station. Wire slack shall be sufficient to allow removal and extension of wire for testing.

C. Wire shall not be bent into a radius of less than eight times the overall wire diameter.

D. The wire conduits must be of sufficient diameter to accommodate the wires. This shall be determined by the number and size of wires in accordance with the applicable codes and standards.

3.6 WIRE IDENTIFICATION TAGS

A. All wires shall be coded with wire identification tags within 4 inches of the wire end indicating diameter and type of pipe.

B. Wire identification tags shall be placed on all wires prior to pulling wire runs and installation of test stations.

3.7 EXOTHERMIC WELD CONNECTIONS

A. Exothermic weld connections shall be installed in the manner and at the locations indicated. Exothermic welds shall be spaced at least 6 inches apart from other exothermic welds.

B. If present, coating materials shall be removed from the surface over an area of sufficient size to make the connection and as indicated on the Drawings. The surface shall be cleaned to bare metal per SSPC SP11 prior to welding the conductor. The use of resin impregnated grinding wheels will not be allowed.

C. Only enough insulation shall be removed such that the copper conductor can be placed in the welding mold. If the wire conductor diameter is not the same as the opening in the mold, then a copper adapter sleeve shall be fitted over the conductor.

D. The CONTRACTOR shall be responsible for testing all test lead and bond wire welds. VTA, at its discretion, shall witness these tests. After the weld has cooled, all slag shall be removed and the metallurgical bond shall be tested for adherence by the CONTRACTOR. A 22-ounce hammer shall be used for adherence testing by striking a blow to the weld. Care shall be taken to avoid hitting the wires. All defective welds shall be removed and replaced in a new location at least 6 inches away from the original weld location.

E. All exposed surfaces of the exothermic weld, copper wire, and at least an inch away from the edge of the exothermic weld on reinforcing steel shall be covered with insulating epoxy putty. The epoxy putty shall be cured before pouring concrete.

F. If the reinforcing steel had a coating prior to exothermic welding, the CONTRACTOR shall inspect reinforcing steel to confirm that all coatings removed or damaged as a result of the welding have been repaired. The CONTRACTOR shall furnish all materials, clean surfaces, and repair protective coatings damaged as a result of the welding. Repair of any coating damaged during welding shall be performed in accordance with the coating manufacturer’s recommendations.

G. After pouring concrete around the reinforcing steel, all test lead pairs shall be tested for broken welds using a standard ohmmeter. The resistance shall not exceed 150% of the theoretical wire resistance, as determined from published wire data.

3.8 SYSTEM TESTING

A. Upon completion of the installation, the CONTRACTOR shall provide testing of the completed system by a Corrosion Technician, and the data shall be reviewed by a Corrosion Engineer to ensure conformance with the Contract Documents.

B. The testing described herein shall be in addition to and not substitution for any required testing of individual items at the manufacturer's plant and during installation.

C. Testing shall be performed at all test leads of all test stations as soon as possible after installation of the Stray Current Monitoring System to ensure electrical continuity and that the requirements and intent of the Contract Documents have been met.

D. For every test, record weather conditions: temperature, rainfall (inches), and any other notable condition that may affect the results of the test. Testing shall not be conducted if there is standing water after a rain event.

E. Perform the following tests at each Hinge Bonding Test Station:

1. Verify the electrical continuity of the top layer of reinforcing steel using the linear resistance method.

   a. The test span shall be the distance between consecutive Hinge Bonding Test Stations. A direct current shall be applied through the test span using a lead on each end. The potential across the test span shall be measured using the other test lead on each end. The current applied and voltage drop shall be recorded for a minimum of three different current levels.

   b. Calculate the theoretical resistance of the test span considering the dimensions and quantities of the welded reinforcing steel.

   c. The average measured resistance shall be compared to the theoretical resistance. If the measured resistance is greater than 125% of the theoretical resistance, then the electrical continuity shall be considered deficient and shall be repaired and retested at the CONTRACTOR’s expense. If the measured resistance is less than 100% of the theoretical resistance, then the test and/or calculated theoretical resistance shall be considered deficient and the test span shall be retested and/or recalculated at the CONTRACTOR’s expense.

   d. Alternative continuity testing methods can be submitted to the ENGINEER for consideration and approval.

F. Perform the following tests at each Corrosion Monitoring Test Station:

1. Verify electrical isolation of all reference electrode bar from the guideway’s reinforcing steel before and after pouring concrete.

a. Before pouring concrete, the CONTRACTOR shall test the isolation using a Gas Electronics Model No. 601 Insulation Checker or an approved equivalent. If the testing results indicate less than 100% insulation, then the isolation method shall be repaired and retested at the CONTRACTOR’s expense.

b. After pouring concrete, testing shall be performed by measurement of native reinforcing steel-to-concrete potential and reference electrode bar-to-concrete potential. If the difference in native potentials on each side of the isolation is within ±100 mV, then additional testing shall be performed, as follows. Temporary current shall be circulated on the reference electrode bar. “On” and “Instant Off” potentials shall be measured for the reinforcing steel and reference electrode bar. If the “Instant Off” reinforcing steel-to-concrete potential is more negative than the native potential, the isolation shall be considered deficient and shall be repaired and retested at the CONTRACTOR’s expense.

2. After revenue service has started, place a recording voltmeter between the reference electrode bar and the reinforcing steel in the aerial guideway. Record voltage at an interval less than or equal to once every second for a minimum of 10 minutes and until at least one train has passed in each direction.

G. Perform Track-to-Earth Resistance testing in accordance with Section 34 11 40.

H. The CONTRACTOR shall provide a written report, prepared by the Corrosion Engineer, documenting the results of the testing and recommending corrective work, as required to comply with the Contract Documents. Any deficiencies of systems tested shall be repaired and re-tested by the CONTRACTOR at no additional cost to VTA. The report shall include the graph of each recording and provide the raw recording data in Microsoft Excel or Comma Delimitated Values (CSV) format to VTA for approval.

END OF SECTION 26 42 00

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SECTION 26 50 00

LIGHTING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing and installing lighting systems, including light fixtures, drivers and light poles for City Street Lighting as well as Station Lighting as indicated on the Drawings. The light poles for station lighting shall include standard brackets, metal supports for Public Address (PA) speakers, and metal supports for CCTV cameras as shown on the Drawings.

B. This section includes requirements for furnishing room lighting in the various rooms including the electrical room, signal and communication room and elevator machine rooms.

C. This section includes requirements for furnishing Pedestrian Over Crossing (POC) lighting including hand rail lighting and soffit lighting.

D. This section also includes requirements for design of light poles and light standard brackets.

1.02 REFERENCED STANDARDS

A. National Electrical Code (NEC).

B. Illuminating Engineering Society (IES)

C. Santa Clara Valley Transportation Authority (VTA) Light Rail Transit Design Criteria Manual (2004)

D. City of San Jose Standard Specifications (CSJSS), Section 86-6 Lighting

E. City of San Jose Standard Details (CSJSD), Electrical Signals and Lighting

1.03 DESIGN REQUIREMENTS

A. The design of light poles and light standard brackets including metal support shall account for all dead, live, wind, seismic loads, and temperature effects. Wind loads shall include wind loads on signs.

1.04 SUBMITTALS

A. Product Data: Submit descriptive literature of cataloged products, equipment drawings, diagrams, performance and characteristic curves and catalog cuts.

B. Test Report: Submit test report of lighting levels.

C. Design Calculations and Shop Drawings for Light Poles at Stations:
   1. Submit design calculations and detailed shop drawings of light pole and light standard brackets including metal supports for showing sizes, details of fabrication and construction, methods of assembly, locations of hardware, anchors, and accessories.

2. Calculations and drawings shall be stamped and signed by a civil or structural engineer licensed in California. Contractor shall be responsible for the final design of light pole and light standard brackets including metal supports.
3. Show hand-holes and openings and show provisions for maintaining separation between cables inside the poles as specified herein.

1.05 DELIVERY, STORAGE AND HANDLING

A. Ship and store materials to prevent damage due to stains, discoloration, scratches, dirt, and other causes. Store assembled components indoors in a clean, dry location. Store and handle materials to prevent abrasion or other damage.

1.06 COORDINATION

A. Coordinate installation with other work such as precast concrete, cast-in-place concrete, mechanical work and site furnishing fabrication.

B. Paint exposed metal surfaces in accordance with Section 09 91 00, Painting, unless otherwise specified. Coordinate shop painting with painting of other trades.

1.07 MEASUREMENT AND PAYMENT

A. Full compensation for all work under this section shall be considered as included in the prices paid for various contract items of work involved and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 GENERAL

A. All lighting shall have a color temperature of 4,000 degrees K unless otherwise noted.

B. All lighting shall have a minimum CRI (Color Rendering Index) 70.

2.02 STATION LIGHTING

A. Light fixtures and poles as specified on the Drawings.

B. Provisions shall be made to include hand-holes and openings in the poles for ease of installation and for wiring of all fixtures and devices. Fuses shall be accessible from the pole base hand-hole.

C. Handrail lighting shall be as specified on the Drawings.

D. The light fixtures shall be the models listed on the light fixture schedule or approved equal.

E. Fuses:

1. All fixtures shall have fuses. For those fixtures not installed on poles, the fuses shall be installed in the housing or pull box.

2.03 STREET LIGHTING

F. Street lighting shall be as specified on the Drawings.

G. All new luminaires shall have an ANSI 7-wire receptacle. All luminaires shall also come with luminaire controller via the ANSI 7-wire receptacle. All LED streetlight luminaires shall have luminaire controllers unless noted otherwise.

H. There shall be a mechanism to provide access to the inside of the luminaire. The access mechanism, when closed, shall provide weather proofing for the inside of the luminaire. The fitter shall be able to fit into a 2 inch diameter tenon.

I. All luminaires shall be certified (listed) by a nationally recognized testing laboratory (NRTL) by the Occupational Safety & Health Administration (OSHA).

J. The lamp shall retain at least 90% of its initial lumen output up to at least 90,000 operating hours. The lamp shall have a color temperature of 4,000K and a color rendering index of at least 70.

K. The luminaire must be able to operate normally in temperatures from -20˚C to 50˚C.

L. The luminaire system shall be able to operate on a single phase power source with voltages anywhere between 120 and 277 volts.

M. The housing shall be primarily constructed of metal. Finish shall be gray in color, powder coated and rust resistant. Driver must be mounted internally and be replaceable. Driver must be accessible without tools. All screws shall be stainless steel. Screws fastening drivers, monitoring and control modules, led boards, and other maintainable parts shall be captive type. Polycarbonate shall be UV stabilized (lens discoloration shall be considered a failure under warranty).

N. Cooling System shall have no fans, no pumps, no liquids nor any moving parts and shall be resistant to debris buildup so as not to degrade heat dissipation performance.

O. Luminaires shall mount on 2 inch O.D. horizontal tenon with no more than four 14mm hex bolts and two piece clamp with vertical tilt adjustment range of +/- 5%.

P. Luminaire shall be compliant to International Dark-Sky Association and ARRA buy America compliant.

Q. LED luminaire will have fixture wattage labels that will be visible from the ground.

R. The luminaire shall have an IES type III distribution, as specified in plan, and dimming capabilities available.

S. The luminaire must be able to accept a 0-10 volt dimming signal. The luminaire shall be operational even without the dimming signal and will operate at maximum intensity.

T. The minimum power factor will be 0.9.

U. A warranty must be provided for the full replacement of the luminaire due to any failure for a minimum of five (5) years.

PART 3 - EXECUTION

4.01 GENERAL

A. Inspection: Prior to commencement of Work, carefully inspect the installed work of other trades and the provided products and verify such work is correct and complete. Immediately notify the Engineer of any discrepancy before proceeding with work.

B. Protection: Protect adjacent existing site improvements from damage during installation procedures. Protect fixtures during installation from scratches, nicks, dents and imperfections.

C. Materials and work quality shall be as specified in Section 26 05 00, Common Work Results for Electrical Systems. Verify equipment dimensions prior to installation of equipment.

4.02 REMOVING, REINSTALLING OR SALVAGING ELECTRICAL EQUIPMENT

A. Removing, reinstalling or salvaging electrical equipment is shown on the Drawings.

B. All salvaged equipment must be delivered to the Department of Transportation – Mabury Service Yard, 1404 Mabury Road, San Jose, CA. Contact the Department of Transportation at (408) 794-1969, 48 hours prior to delivery of salvaged equipment.

4.03 INSTALLATION

A. Install light fixtures as indicated on Plans, in accordance with the manufacturer's recommendations and hereinafter.

B. Install fixtures plumb, true, level, square and in true alignment and firmly anchored to withstand 1.6 kg/cm2 (on full surface) basic wind pressure.

C. Install fixtures complete, water tight with all electrical work and appurtenances and be fully operative.

D. Fixture lenses shall not be fastened by drilling holes in the fixture frame.

E. Provide LEDs for all fixtures of the designed rating and pattern. LEDs shall be delivered to the project in the original cartons just prior to the completion of the project.

4.04 CHECK-OUT

A. Check all bolts, nuts and other connections for proper fit and tightness.

B. Check components for proper alignment, fit and tolerances.

4.05 LIGHTING LEVELS

A. Following completion of lighting installation, measure horizontal lighting levels in lux on a 8 feet grid along the length of the platform and at exit and entry walkways starting 4 feet inside the control points at the station platforms and access structures. Results of the measurements shall be submitted to the Engineer for approval.

END OF SECTION 26 50 00

SECTION 27 05 00

COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes selected system-level and more detailed common technical requirements for the Communications System and its subsystems including:

1. Cable Transmission System (CTS).
2. Central Control System (CCS).
3. SCADA Monitoring and Control System including, TES SCADA, Train Control/Signal SCADA, Station SCADA, and Wayside SCADA.
4. Public Address System.
5. Passenger Information Monitor System.
6. Telephone System.
7. CCTV System.
8. Intrusion Detection System.
9. Automated Fare Collection System.

B. This Section includes an overview and fundamental requirements of the design review submittals and process for implementation of the Communications System, including the Hardware/Software Preliminary Design, Hardware/Software Final Design, more detailed Shop Drawings, and As-Built Record drawings and specifications.

C. Requirements, technical processes, and submittals defined in this Section are minimum requirements intended to be complemented by (rather than supersede or be superseded by) requirements, processes, and submittals defined elsewhere in these Contract Documents.

1.02 RELATED SECTIONS

A. Section 27 05 28, Pathways for Communications Systems.

B. Section 27 11 16, Communications Cabinets, Racks, Frames and Enclosures.

C. Section 27 11 19, Communications Terminal Blocks and Patch Panels.

D. Section 27 13 00, Communications Network Cabling.

E. Section 27 15 00, Communications Low-Voltage Conductors and Cables.

F. Section 27 21 00, Communications Network Equipment.

G. Section 27 26 00, Communications Programming and Integration Services.

H. Section 27 30 00, Telephone System.

I. Section 27 42 19, Public Address System.

J. Section 27 42 20, Passenger Information Monitor System.

K. Section 28 20 00, Video Surveillance (CCTV).

L. Section 28 31 00, Intrusion Detection System (IDS).

M. Section 28 40 00, SCADA Monitoring and Control System.

N. Section 34 54 00, Automated Fare Collection System.

1.03 REFERENCED STANDARDS

A. The latest versions of the following standards and references apply to the work included in this Section, in addition to those codes and standards common to all communications subsystems specified in section 27 05 00 "Common Work Results for Communications". If a conflict must arise between various standards, the California state code amendments must govern, or the most strict/conservative requirement must govern.

B. American National Standards Institute (ANSI):

1. TIA-606 — Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.

C. Federal Aviation Administration (FAA):

1. Human Factors Design Guide.

D. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

1. 200 — Reference Designations for Electrical and Electronics Parts and Equipment.
2. 830 — Recommended Practice for Software Requirements Specifications.
3. 1016 — Recommended Practice for Software Design Descriptions.
4. 1228 — Standard for Software Safety Plans.

E. Department of Defense, Military Standards (MIL):

1. MIL-STD-1472 — Design Criteria Standard, Human Engineering.

F. Software Engineering Institute's (SEI):

1. SW-CMM — Capability Maturity Model for Software.
2. CMU/SEI-93-TR-024 — Capability Maturity Model for Software (Version 1.1).
3. CMU/SEI-93-TR-025 — Key Practices of the Capability Maturity Model (Version 1.1).

1.04 QUALITY ASSURANCE

A. The Contractor must comply with the requirements of the approved Contractor Quality Assurance Plan and other project management submittals as approved by VTA.

1.05 SUBMITTALS

A. General:

1. For each submittal and submittal type listed, submit in accordance with Section 6.6.2, Submittal, of the Special Conditions, unless specifically required otherwise in the "Technical Submittals List."

2. For each design review submittal, allow an additional 4 days, over and above that defined in Section 6.6.2, Submittal, of the Special Conditions, for review and appropriate action by the VTA.

3. Resubmittals must be full packages (e.g., not just changed or added portions), with all changed or added pages explicitly listed and marked.

B. Cutover Plan and Cutover Documentation: Refer to Section 01 12 16, “Work Sequence and Cooperation.”

C. Design Review Submittals: The minimum set of design review submittals is listed below. Individual Communications subsystems may have additional requirements defined elsewhere in these technical specifications.

1. Design review submittals must include:

   a. Conceptual Design Review submittal package.

   b. Hardware Preliminary Design Review submittal package, for each subsystem and for each type of Communications Node (e.g., Cabinet, Communications Room,). For each type of Communications Node, include cabinet/rack/shelf equipment, external connections, location of all equipment within the node, rack mechanical layouts and supports, rack face elevations, electrical interconnections, wire and cable termination hardware, cable routing and cable management, power equipment and power distribution, sensor equipment, HVAC equipment and grounding design. Also, provide: a block diagram for each Communications Node showing all Communications equipment in the node, all communications equipment supported by the node, and all external interfaces; and for each node provide a parts list and mapping of parts list to block diagram and Communications Node physical layouts.

   c. Hardware Final Design Review submittal package, for each subsystem and for each type of Communications Node. The Hardware Final Design Review submittal package for a subsystem must not be submitted until both the Software Preliminary Design Review submittal package and the Hardware Preliminary Design Review submittal package for that subsystem have been approved by the VTA.

2. Prior to the Hardware Final Design Review submittal package for the Communications Node located in a Communications Cabinet, the Contractor must submit a thermal model for the fully populated Communications Cabinet. The model must predict thermal operating characteristics within the cabinet for maximum ambient air temperature external to equipment and solar radiation conditions.

3. Unless otherwise specified, design review submittal packages must be submitted two weeks prior to the corresponding design review meeting.

4. Up-to-date software and hardware preliminary design review materials must be included with each Final Design Review submittal package.

5. Each submittal package, including resubmittals, must be a complete set.

D. Workmanship Standards, Practices and Procedures: The Contractor must submit manuals and/or documents which comprehensively describe assembly and installation workmanship standards, procedures, and practices applicable to the Communications System. All standards, practices and procedures are subject to review and approval of the VTA as applied to work performed on this Contract.

E. Installation Work Plan:

1. An Installation Work Plan must be submitted.

2. The Installation Work Plan must include the following information:

   a. Installation staff, their roles, and the status of all training required prior to access to the work site.

   b. Safety rules, regulations, and procedures.

   c. Permits and licenses: Obtained and still to be obtained (with dates when they will be obtained).

   d. Planned access dates and times for each location.

   e. VTA resources required for each location.

   f. Traffic Control procedures.

   g. Daily Preparation and Cleanup procedures.

   h. Records and Reports.

   i. Storage/staging facilities and security.

   j. Job-site security.

F. Installation Documentation:

1. Installation documentation must be provided for all wire, cable, equipment, enclosures and cabinets to be installed. An installation documentation set must be provided for Communications System elements as follows:

   a. Installation documentation must be provided for all wayside cable. Unless otherwise approved by the VTA, installation documentation must be provided from one Communications Node to the next. The Contractor may propose other groupings of installation documentation, provided that all installation represented is geographically contiguous and is continuous in time within that area.

   b. Installation documentation must be provided for all other cable, including for each station (including cable between platforms), from each Communications Node to supporting facilities such as TES substations, Operator Break Facilities, and Signal facilities. Installation documentation must be organized into sets separating one cabling associated with one Communications Node from another.

   c. Installation documentation must be provided for each Communications Node and must include installation of the following. Within each node, installation documentation must be logically grouped (e.g., one subsystem separated from another).

      1) For Communications Nodes located in a Communications Cabinet, the cabinet itself as well as all interior racks if not delivered as part of the cabinet.

2) For Communications Nodes not located in a Communications Cabinet, racks, cabinets, and enclosures.

3) Wire and cable, and cable management hardware.

4) Terminal blocks, local distribution frames, distribution panels, slack enclosures and related hardware.

5) Equipment shelves and chassis.

6) CTS equipment, Station SCADA LAN equipment, Station IT LAN, and all data communications equipment within the Communications Node. Include installation documentation for all data communications equipment at Signal System facilities and other facilities (except TES substations) served by this Communications Node.

7) Power supplies, UPS, power strips, power connections and other power system equipment.

8) Grounding equipment and connections.

9) Sensor equipment, HVAC equipment and any other node equipment not included in another installation documentation set.

d. Installation documentation must be provided for each Communications PLC, and must include all equipment and I/O wire and cable within the associated Communications Node as well as wire and cable to wayside and station field devices. The documentation set for each Communications PLC may be included in the documentation set for the corresponding Communications Node.

e. Installation documentation must be provided for the PA/PIM subsystem at each station, and must include all wire, cable and equipment at the station. Cable and equipment in the Communications Node may be included in the PA/PIM documentation set or in the corresponding Communications Node documentation set.

f. Installation documentation must be provided for telephones at each station, and must include all wire, cable and equipment at the station. Additionally, this documentation must include installation of all other telephones (except at TES substations) and telephone cable and wire served from the corresponding Communications Node.

g. Installation documentation must be provided for CCTV cameras at each station, and must include all wire, cable and equipment at the station, including Digital Video Recorders and other equipment pertinent to the CCTV system.

h. Installation documentation must be provided for each substation, and must include all wire, cable and equipment at that substation, including PLC equipment and telephone equipment.

i. Installation documentation must be provided for each IDS location, and must include all wire, cable and equipment at that IDS station, including IDS Cabinet equipment, IDSS Assembly and IDS CCTV equipment.

2. Each installation documentation set must include:

a. Installation procedures.

b. Installation drawings.

c. Location-specific configuration data and equipment settings.

d. Installation inspection and test procedures.

e. Inventory data.

3. Installation may not be started prior to the VTA's approval of the installation documentation for the subject equipment for the subject location.

4. Installation documentation applicable to a location must not be submitted prior to approval by the VTA of:

a. The Final Design Review submittal package for all subsystems included or represented at that location.

b. The Communications Node-type Final Design Review submittal package for applicable to the type of Communications Node at that location.

5. Installation inspection and test records must be completed on a daily basis, and must be provided upon request.

G. Procedures for removal of equipment must be submitted.

H. Test Plan, Procedures and Test Reports for all subsystems, systems, and integration of systems as further described in general testing requirements section TBD for:

1. Factory Acceptance Tests.

2. Field Installation Tests.

3. Field Functional Tests.

4. Systems Integration Tests (Per Station).

5. Systems Integration Tests (to OCC).

I. Operations & Maintenance Manuals as further described section 01 78 23, to include:

1. Separate section for each subsystem and system.

2. Interfaces between systems.

3. Site specific, project specific information.

J. Training Plan, Courseware, and Training Classes as further described section TBD.

1. Operations Personnel Training.

2. Maintenance Personnel Training.

3. Courses required to fulfill requirements of the California Public Utilities Commission General Order 164E regarding emergency operations training, emergency simulation, incident response, and coordination with local fire, police, EMS, city and county. These courses would include command and control functionality of the integrated communications systems.

K. As-Delivered versions of the following documentation must be submitted:

1. Equipment inventory with serial numbers.

L. Equipment Identification Plan. Include:

1. Identification scheme.

2. Proposed labeling/tagging/marking method for each type of equipment.

M. As part of the As-Built documentation set required by Section 01 33 00, "Submittal Procedures," provide as-built versions of the following documentation:

1. All design documentation, including drawings, SRSs and functional specifications, software design documentation, hardware design documentation, equipment descriptions, and equipment and software configuration documentation.

2. All installation documentation, including drawings and procedures.

3. All installation and test records.

4. All field test records.

5. Equipment inventory with serial numbers:

    a. Delivered.

    b. Installed and successfully tested.

    c. Replaced.

    d. Spares.

6. System software inventory, and configuration data and settings for all system software.

7. All databases and other forms of configuration data.

8. All configuration settings (and definition of the possible ranges for each) and parameter settings (and definition of the possible ranges for each) for equipment, firmware, and software.

9. All procedures for:

    a. Installing software and firmware.

    b. Updating software and firmware versions.

    c. Installing database data and other configuration data.

10. All customized manuals.

11. Any other documentation developed or modified for this Contract to facilitate VTA's operation of, maintenance of, or update of the Communications System.

1.06 MEASUREMENT AND PAYMENT

A. Measurement: Common Work Results for Communications must be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Common Work Results for Communications must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in this Section complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by VTA, and no additional compensation must be allowed therefore.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION

A. SYSTEM SIZE

1. Existing VTA Light Rail System Size:

   a. Number of Stations: 63.

   b. Number of Signal facilities (e.g., bungalow/house, case, or room) which contain Signal System equipment (e.g., Event Recorder, VP, CTP, or TWC) and whose device statuses are monitored by the Central Control System: 64.

   c. Number of traction power substations: 32.

   d. Number of yards: 1.

B. GROWTH

1. The communications system design must support future physical growth of the VTA LRT system to at least 200 percent of the existing VTA Light Rail System Size defined above.

2. This physical growth of the System must be able to be achieved in a manner meeting all the following requirements:

   a. By adding equipment.

   b. Without the need to replace or remove equipment provided under this Contract (and without loss of use of that equipment).

   c. Without software code changes.

3. This physical growth must be able to be achieved while the VTA light rail system (consisting of both the existing LRT system and the Extensions) continues to operate.

C. RESPONSE TIMES

1. For the existing system software designed and provided under this project, the response time requirements must be the same as the response times already established under the previous S945 project. There must be no degradation in the system performance as a result of software updates associated with the current project.

2.02 SOFTWARE DESIGN

A. Application Software: All software not categorized as system software must be considered application software. Under the current project, it is expected that no system software coding (changes to the software source code) will take place, only the application software programming and configuration will take place. It is expected that the Contractor will utilize the application software provided to VTA under the previous contracts or will purchase Commercial-off-the-Shelf (COTS) application software for the new systems, if required (e.g. updates to the CCTV system).

B. Application software provided under this contract must:

1. Comply with current open systems technological standards.
2. Use Application Programming Interfaces (APIs) designed to preclude vendor specific or non-portable solutions.
3. Use Communications Services Interface (CSI) (e.g., entities include external data transport facilities and devices, the protocol state, syntax and format) standardized for system interoperability.
4. Be portable, allowing for movement across computing platforms with minimal modifications.
5. Be configurable, allowing operation on numerous platforms depending on VTA's requirements.
6. Be able to use a common set of services that improve the opportunities for interoperability.
7. Have capabilities defined in terms of non-proprietary specifications that support full and open competition.
8. Be modular, to allow upgrades of hardware and system software.
9. Utilize configurable parameters for values such as: delays, timeouts, retry counts, and intervals.
10. Provide for configurable error message contents.
11. Employ a configurable software process structure to facilitate load balancing across hardware platforms.
12. Include built-in monitoring points to facilitate performance monitoring and diagnosis.
13. To the extent practical, use configurable data rather than hard coded data.

2.03 OPERATION - CCS AND PAC INTEGRITY OF OPERATION

A. The system must not initiate an unintended I/O control action.

2.04 IDENTIFICATION

A. General: Numbering scheme and format for all types of equipment identification must be submitted to the VTA.

B. Labeling Components, Subassemblies, and Assemblies: All components, subassemblies, and assemblies must be appropriately labeled so that they may be readily identified. Part reference designations must be assigned in accordance with ANSI Y32.16 and must be marked on the product unless otherwise approved by the VTA. Reference designations for parts unique to an indicated location must be preceded by the location identifier.

C. Controls and Adjustments: Controls and adjustments must be clearly identified as to function and must be marked or indexed so that the control position or direction of rotation can be readily identified. Fixed guide marks on controls or adjustments must be provided if the controls or adjustments require presetting for a standard maintenance operation.

D. Indexing: Mechanical assemblies subject to maintenance disassembly must be indexed to ensure proper relative positioning of parts after re-assembly.

E. Access Labeling: Labeling at accesses must be provided and must include, but not be limited to essential maintenance information, including but not limited to names of items inside; reference to schematic wiring diagrams and servicing procedures; and warning of hazardous or critical operations.

F. Equipment Cabinets: Each equipment cabinet must have a unique I.D. tag located top center front and rear on exterior of cabinet frame. The tags must be engraved metal tags. Lettering must be in block letters 13 mm (1/2 in.). Each I.D. text must consist of two lines; the first line to show cabinet number, and the second line to show specific name of the cabinet, as indicated. Cabinet name and number must correspond with the cabinet terminology indicated on the Contract Drawings.

G. Junction and Pull Boxes: Each junction and pull box must have a unique number tag on the cover. The tag must be engraved metal. Lettering height must be 25 mm (1 in.). Numbers must identify the service of circuits within the box and the location of the box by civil stationing. Pull boxes must be stenciled to show unique identification and civil stationing.

H. Relays: Relays must be provided with name tags or engraved plastic "lamicord" engraving. Tags must be of stamped or engraved metal plates. Information on tags or engraving must include type, rating, part number, date and place of manufacture.

I. Communications termination hardware, cable, pathway, space, grounding, and termination position identifiers must be in accordance with ANSI TIA-606.

PART 3 - EXECUTION

3.01 DESIGN REVIEWS

A. This subsection defines the minimum set of design reviews to be conducted by the Contractor, and the minimum information and process requirements for those reviews. Where requirements posed by individual subsystems, as defined in other sections of these technical specifications, are different or greater than those specified in this subsection, those other requirements must be deemed to augment the requirements specified herein.

B. Conceptual Design Review: The following information must be provided in the Conceptual Design Review submittal package:

1. Communications System single-line diagram showing all nodes, all head-end, all end equipment (e.g., PIM, PA speaker) and all equipment to which the Communications System interfaces.

2. Functional block diagrams for CTS, CCS, the Station SCADA LAN, the Station Gigabit Ethernet LAN, the PA system, PIM system, the CCTV system, the IDS system and PAC equipment and system.

3. Identification of the functional and physical boundaries of each Communications subsystem.

4. Identification and specification of all external interfaces (e.g., to those to facilities and equipment provided by others). External interfaces must include those for:

a. Power.

b. Grounding.

c. Cable facilities.

d. Data and discrete signals.

e. Data communications.

f. Conduit runs.

g. Equipment support/fasteners.

h. Space.

5. Preliminary cable plan, including: All to/from locations with cable types for each routing and pathway.

6. Results of the Contractor's attenuation and OTDR tests for all inactive fibers of the existing single mode fiber optic cable.

7. Allocation of system response time requirements across subsystems (i.e., allocating performance budgets for each subsystem, including PAC Equipment, CTS, CCS, CCTV and PA/PIM equipment).

a. Response time budget allocations must be included for each of the selected Communications System actions defined in this Section.

b. Response time budget allocations per subsystem must be supported by corresponding data, including:

1) Equipment manufacturer published equipment specifications as applicable to equipment presenting fixed delays (e.g., not load sensitive).

2) Calculated full load response time values based on values measured from test implementation of the system using the proposed equipment and software.

8. Cutover Approach, including identification of the major architectural and functional characteristics of the Communications System to support continuous operation of the LRT system and existing communications system.

C. Hardware Preliminary Design Review for Each Communications Subsystem: Each Hardware Preliminary Design Review submittal package must contain:

1. For those subsystems where a Software Requirements Specification was not produced, a detailed Functional Specification must be provided. The Functional Specification must include specification of:

a. All functions, to the point where there is no remaining ambiguity or interpretation, and covering all cases and bounds.

b. All external interfaces in terms of the functions, behavior, and performance of the interface.

c. All inputs to the subsystem, and all outputs produced by the subsystem.

d. All user interfaces (e.g., displays, controls, and indicators) and their behavior.

e. All facilities, interfaces, functions, and tools supporting monitoring, maintenance and management of the subsystem.

f. All performance requirements (e.g., response times, capacity and throughput, ability to support growth, reliability and availability, and integrity of operation), and corresponding analyses.

2. For subsystems with which a user must interface:

a. Prototype screen displays on the target equipment (if a screen display is present in the user interface).

b. Sample of user interface devices and components.

3. Physical block diagrams showing:

a. All equipment modules.

b. All interfaces between modules.

c. All external interfaces.

d. All cables between modules.

e. All cables which go outside the physical boundaries of the subsystem.

4. Top level mechanical drawings, including those depicting all external physical / mechanical interfaces.

5. Identification and specification of all external interfaces.

6. Description and specification for all equipment and components.

7. Reliability calculations showing conformance to specified equipment reliability requirements.

8. List of recommended Field Replaceable Units; list of recommended replaceable units down to and including the Lowest Level Replaceable Units.

D. Final Design Review for Each Communications Subsystem: The Final Design Review for each subsystem must include review of the Hardware Final Design Review submittal package for that subsystem as well as, where applicable, the Software Final Design Review submittal package for that subsystem.

1. The Software Final Design Review submittal package must include the Software Design Description, containing (in addition to software design information provided in the preliminary version):

a. Algorithmic logic for all modules down to at least the fourth level of decomposition.

b. All algorithmic logic which is used to implement an external interface or a function where the results are externally visible (e.g., a report, train movement), and all algorithmic logic which has an impact on operation, maintenance, performance, growth, availability or integrity of operation.

c. Description of all code libraries (such as Class Libraries and Component Libraries).

2. The Hardware Final Design Review submittal package must:

a. Provide details for all block diagrams, including parts lists.

b. Provide mechanical details.

c. Provide details of all interfaces (e.g. electrical, mechanical, spatial, power, grounding, and thermal) and requirements of other LRT systems and facilities.

d. Provide details of all cable routing and associated facilities such as raceways, cable trays, conduit, junction boxes and floor boxes.

3. The final design review design documentation submittal package must identify all configurable settings for all equipment and for any commercial off-the-shelf software which may be part of the subsystem. Values (for configurable settings) not specific to a particular Communications Node or other particular location (except the central Equipment Room) must be included.

4. The final design review design documentation must be sufficiently detailed and complete to allow for manufacture (including software coding) without the ability for interpretation in the manufacturing facility which can reduce the performance, alter the externally visible functioning, or alter the external interface of the manufactured equipment or subsystem.

5. The final design review design documentation must include a comprehensive drawing package, up-to-date descriptions and specifications from the preliminary design, and sample components.

END OF SECTION 27 05 00

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SECTION 27 05 28

PATHWAYS FOR COMMUNICATIONS SYTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes the requirements for furnishing, installing and testing complete conduit, microduct and innerduct systems.

B. This Section includes the requirements for providing overhead cable trays within Signal/Communication Rooms and Information Technology Rooms at Stations for communications equipment.

C. This Section includes the requirements for providing cable racks and supports for in-ground CSD vaults and Guideway CS pullboxes.

D. This Section includes specification requirements for:

1. 7 Cell Microduct
2. Semi Rigid Innerduct
3. Fabric Innerduct
4. Communications Rooms Cable Trays

1.02 RELATED SECTIONS

A. Section 27 05 00, Common Work Results for Communications

B. Section 27 11 16, Communications Cabinets, Racks, Frames and Enclosures

C. Section 27 11 19, Communications Terminal Blocks and Patch Panels

D. Section 27 13 00, Communications Network Cabling

E. Section 27 15 00, Communications Low-Voltage Conductors and Cables

F. Section 27 21 00, Communications Network Equipment

G. Section 27 26 00, Communications Programming and Integration Services

H. Section 27 30 00, Telephone System

I. Section 27 42 19, Public Address System

J. Section 27 42 20, Passenger Information Monitor System

K. Section 28 20 00, Video Surveillance (CCTV)

L. Section 28 31 00, Intrusion Detection System (IDS)

M. Section 28 40 00, SCADA Monitoring and Control System

N. Section 34 54 00, Automated Fare Collection System

1.03 REFERENCED STANDARDS

A. The latest versions of the following standards and references apply to the work included in this Section, in addition to those codes and standards common to all communications subsystems specified in section 27 05 00, Common Work Results for Communications. If a conflict must arise between various standards, the California state code amendments must govern, or the most strict/conservative requirement must govern.

B. American National Standards Institute (ANSI):

1. C80.1 Rigid Steel Conduit - Zinc Coated.
2. C80.3 Electrical Metallic Tubing - Zinc Coated.

C. American Society for Testing and Materials (ASTM):

1. A123/A123M Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
2. A780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
3. D256 Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics.
4. E814 Standard Test Method for Fire Tests of Through-Penetration Fire Stops.
5. F512 Standard Specification for Smooth-Wall Poly (Vinyl Chloride) (PVC) Conduit and Fittings for Underground Installation.

D. California Public Utilities Commission (Cal. PUC):

1. G.O. 128 Construction of Underground Electrical Supply and Communications Systems, Rules for.

E. National Electrical Manufacturers Association (NEMA):

1. FB 1 Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies.
2. TC 6 PVC and ABS Plastic Utilities Duct for Underground Installation.
3. VE 1 Metallic Cable Tray Systems.
4. VE 2 Metal Cable Tray Installation Guidelines.

F. National Fire Protection Association (NFPA):

1. 70 National Electrical Code.
2. 70B Electrical Equipment Maintenance.

3. 262 — Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

G. Underwriters Laboratories Inc. (UL):

1. 1 — Flexible Metal Conduit.
2. 6 — Rigid Metal Conduit.
3. 514A — Metallic Outlet Boxes.
4. 514B — Fittings for Conduit and Outlet Boxes.
5. 514C — Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers.
6. 651 — Schedule 40 and 80 Rigid PVC Conduit.
7. 910 — Test for Flame-Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air.
8. 1666 — Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts.

1.04 QUALITY ASSURANCE

A. General: Contractor's materials, design, installation, and testing must comply with the latest version of all referenced standards and codes, as applicable, as well as codes and regulations of the jurisdictional authorities.

B. Manufacturer: Select a firm regularly engaged in the manufacture of conduit, conduit fittings, connectors, and accessories of the type specified herein indicating conformance and compliance with the technical specifications indicated herein.

1.05 SUBMITTALS

A. Conduit Product Data: Submit product information for each type of conduit, microduct and innerduct to be used. Identify dimensions, material, parts lists, finishes and hardware.

B. Cable Tray Product Data: Submit manufacturer's product and catalog data for proposed materials, with installation recommendations. Identify dimensions, material, parts lists, finishes and hardware.

C. Communications and Equipment Room Cable Tray Layouts: As part of the PDR package submitted for each particular location (refer to Section 27 05 00, Common Work Results for Communications, for PDR submittal requirements), include the following:

1. Layout drawings of cable tray and accessories including clamps, brackets, hanger rods, splice plate connectors, expansion joint assemblies, and fittings, showing accurately scaled components.
2. As part of the FDR package submitted for each particular subsystem or location, include updated versions of the information submitted for the PDR. Include the details of connections, terminations and access points.

D. Manhole Racking Product Data: Submit product data on the proposed racking and support to be installed in CSD manholes. Include proposed installation details and methods for each type of manhole or pullbox (where applicable).

E. Communication Cabling Layouts for the Combined System Ductbank and Communications/Signal Cable Trough:

1. Layout drawings of cable routing to achieve required separation of communications, fiber optic and power cabling indicated on the communications drawings.

2. Coordination with cable layouts for the Signal System, and other systems that may be routed through communications/signals vaults, troughs, trays and conduits.

3. Separation of communications and signal system, particularly at lateral connections to Signal/Communications rooms and IT/Technology Rooms, traction power substations, signal cases, and IDS equipment locations.

F. Test Reports: Submit test reports verifying conduit and cable tray grounding and continuity, per the requirements of Section 26 05 26, Grounding and Bonding for Electrical systems.

1.06 DELIVERY AND STORAGE

A. Delivery: Deliver conduit, microduct, innerduct, boxes, cable tray systems and components carefully to avoid breakage, denting and scoring finishes. Do not install damaged equipment.

B. Storage: Store materials in original cartons and in clean dry space; protect from weather and construction traffic.

1.07 MEASUREMENT AND PAYMENT

A. Measurement: Common Work Results for Communications must be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Common Work Results for Communications must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in this Section complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by VTA, and no additional compensation must be allowed therefore.

PART 2 - PRODUCTS

2.01 GENERAL DESIGN REQUIRMENTS

A. Furnish and install conduit, raceways, microduct, innerduct and all other pathways for all power, and communications cabling within (but not limited to) Communication Rooms at passenger stations, TPSSs, in the at grade CSD, in the guideway Cable Trough, on the elevated guideway for OCS poles for disconnect switches, CCTV, Signal Case and IDS; including interfaces to the Combined System Duct (CSD) and Guideway Cable Trough, unless specified or indicated otherwise.

B. Provide all conduits, raceway, and pathways for communications cable installed under this Contract, whether specified or not, to reach all communications/IT field equipment outside of communications rooms, and communications/IT equipment within communications/IT rooms, as well as power feeds to reach that same equipment.

C. Do not use conduit smaller than 3/4 in. in diameter for interior work and not smaller than 1 in. in diameter for exterior work, unless shown otherwise on the Contract Drawings.

D. Polyvinyl Chloride (PVC): Polyvinyl chloride material is prohibited from use inside Communication Rooms, TPSSs, Signal Houses/Rooms/Cases, Operator Break Rooms, and at the YMF.

E. PVC Coating: For all installations of metal conduit that will be in direct contact with earth, use only galvanized rigid steel conduit and fittings with factory-applied exterior and interior PVC coating as NEC listed.

F. Liquid Tight Flexible Steel (LFMC) or Rigid Steel (GRS and PVC coated GRS) conduit must be provided and installed, extending from conduit provided by others, to reach the final placement of communications devices and enclosures, including:

1. From conduits provided by others throughout passenger stations, to reach the final location of all communications devices, enclosures, and pedestals. Add junction boxes at the end of conduits provided by others as necessary.

2. Extend conduits by others from base of OCS poles to SCADA IDS Cabinets, IT IDS Cabinets, and TPSS Blue Light Stations.

3. Extend conduits by others from base of OCS Poles to manual disconnect monitoring terminations mounted to OCS poles.

4. Extend conduits by others from base of IDS beam sensor poles to reach sensors. Add a junction box to stub up provided by the CSD/CS drawings, and extend conduit to reach all sensors.

G. All other locations to reach all other communications device, enclosures, cabinets or equipment.

2.02 7-MICRODUCT INNERDUCT

A. Provide 7-Microduct Innerduct within CSD conduit #8, and within the Guideway Cable Trough, for the length of the entire project, from the Alum Rock station equipment room, to the end of the project south of Eastridge stations. The 7-Microduct Innerduct must meet the following requirements:

1. 7-Microduct Innerduct manufacturer must be registered ISO 9001

2. 7-Microduct Innerduct must be constructed of polymeric materials, which are lightweight, flexible, corrosion resistant and nonconductive. The material must be rated per the National Electrical Code according to the type of installation.

3. 7-Microduct Innerduct must be factory bundled with a polyethylene oversheath and configured for 7 pathways.

4. The anticipated product life of the microduct must be considered 15 years after installation, allowing for jetting (blowing) operations for cable installations and replacements.

5. Appropriate end caps, couplers and fittings such as (but not limited to) "tee" and "90 degree" angle fittings of the appropriate sizes must be provided for installation of fibers and sealing the microduct from dirt and water entering, as required for lateral cable runs and splicing of the microduct.

6. 7-Microduct Innerduct must be A-D Technologies Duraline "Futurepath" 7 cells with 12.7mm outer diameter and 10 mm inner diameter w/Ripcords and 20 gauge copper locate wire or approved equivalent, along with end caps, couplers and fittings provided by the same manufacturer.

2.03 SEMI RIGID INNER DUCT

A. Semi Rigid Inner Duct must be installed for each passenger station to protect the two 144 backbone fiber cables branching out from the 7-Microduct Innerduct, and must also be installed as required for any fiber optic cable that is not armored, outside of the station platforms. The Semi Rigid Innerduct must have the following characteristics:

1. Corrugated or smooth walled semi-ridged constructions of flame retardant PVC or FCP material and must meet the following flammability requirements:

    a. OSP, inside building horizontal, and inside building riser inner duct must meet the UL 1666 flame test.

    b. Inner duct installed in any air plenum environment must meet UL 910 (NFPA 262).

2. The Contractor may employ integrated multiple inner duct assemblies instead of separate inner ducts when installed in a single conduit.

3. Compatible with the fiber optic cable installed within.

4. Inner diameter as indicated on the Contract Drawings or specified herein.

5. Couplers, if used, must not reduce the inside diameter of the inner duct.

6. All unused inner duct must be preinstalled with lubricated pull tape or line.

7. Compatible couplers and fittings such as (but not limited to) "tee" and "90 degree" angle fittings of the appropriate sizes shall be used to transition from Microduct to Semi Rigid Inner Duct.

2.04 FABRIC INNER DUCT

A. Fabric Inner Duct must be installed within CSD longitudinal conduit, and lateral conduits for stations, TPSS, IDS, CCTV, and Signal Cases to allow future cables to be installed. The fabric innerduct must be pulled as recommended by the manufacturer. Provide minimum of six – 2" pathways for conduit #8 along with the microduct overall sheath and nine – 2" pathways for conduit #9 and for all 4" lateral conduits. Include three – 1" pathways for all 2" conduit. Install required cabling within the fabric innerduct, leave remaining fabric innerduct as spare, tie off the pull tapes. The Semi Rigid Innerduct must have the following characteristics:

1. UL 2024 (OFCR FT-6) Listed.

2. NFPA 76 and NFPA 90A compliance for ceiling cavity plenums and raised floor plenums, and as riser and general purpose applications.

3. Low-smoke, zero-halogen rated.

4. Color differentiated pull tapes pre-installed within each cell.

5. Available in 1”, 2”, 3” and 4” configurations.

6. The Fabric Inner Duct must be MaxCell or approved equal.

2.05 CABLE TRAYS

A. Furnish and install cable tray systems designed to withstand a Seismic Zone 4 earthquake, unless specified otherwise.

B. Cable trays must be of open ladder type, aluminum, or other suitable material commercially available and providing support spacing and strength of material characteristics equal to or greater than the aluminum.

C. The aluminum ladder type cable tray must meet the following requirements:

1. Cable Tray width must be a minimum of 18”.

2. Ladder rung spacing must be approximately 6 in.

3. Standard tray length must be a minimum of 12 ft.

4. Top and bottom flange section of rail must each be a minimum of 1 in. width

5. Height of rail must be a minimum of 4 in.

6. Rung material thickness must be a minimum of 1/8” in.

7. Rung top width must be approximately 1.25 in.

D. Loading Capacities: Cable trays must be capable of carrying a uniformly distributed load of 730 N/m (50 lb./ft.) on a 2.5 m (8 ft.) support span with a safety factor of 1.5 when supported as a simple span and tested per NEMA VE 1-4.01. In addition to the uniformly distributed load, the cable tray must support 890 N (200 lb.) concentrated load at mid-point of span and the centerline of the tray. Load and safety factors specified are applicable to both the side rails and rung capacities. Cable tray must be made to manufacturing tolerances as specified by NEMA, and be seismically rated and braced to also support the top of the racks within the equipment rooms. Provide any required seismic bracing of racks to tray, and from tray to roof of communications room.

E. Each cable tray must be designed and fabricated with sufficient capacity to provide 50 percent of the cross-sectional area as free air space after the full number of cables and wires are installed. Corners must have a minimum radius of 12 in. for either horizontal or vertical turns. Sufficient overhead space must be available after installation to permit wires and cables to be inspected.

F. Where practical, the tray must be constructed in straight sections joined with approved couplers. Electrical continuity of the tray must be maintained across sections by bonding straps.

G. Using the manufacturer's standard, the tray must be laid out using a minimum number of sections, but providing maximum continuous runs without gaps.

H. All fittings, supports, and accessories must be furnished in accordance with the manufacturer's recommendations.

I. To the extent practical, cable trays must be supported by cantilever type brackets in order that the cables can be laid into the tray without pulling.

J. Where the width of the tray, or the loading of cables is such that cantilever supports are impractical, other suspension methods may be used if approved by the Resident Engineer, but such application must be kept to a minimum.

K. At least three supports must be provided for each length of tray. Supports must be evenly spaced insofar as possible. In no case must the spacing between adjacent supports exceed 5 ft.

L. To prevent injury to cables, metal edges must not protrude and sharp corners must not exist in the completed layout.

M. If the Contractor's design and/or system requires separation of wires in the cable trays for electrical interference protection, these barriers must be provided, particularly for 120/240 VAC, Public Address, and CAT 6 data cable/compatible communications conductors.

2.06 CONDUIT SEALS

A. Provide liquid tight, removable seals for every conduit where the 7-microduct innerduct is installed. The seals must meet the following requirements:

1. For use in underground applications.

2. Corrosion and rodent resistant.

3. Custom-built to fit the required microduct as specified herein and any additional cable that is to share the conduit with the microduct.

4. This seal must be Roxtec UG or approved equivalent.

B. Provide liquid tight, removable NEC listed seals for all other communications conduits, at both end of every conduit.

2.07 PULL ROPES

A. Provide pull ropes, tied off, for every empty communications conduit and innerduct, if not installed by others.

B. Install a pull rope or cable having a minimum tensile strength of 2.2 kN (500 pounds). Double back 600 mm (2 ft.) of pull rope at each termination. Do not use nylon rope for pulling wires.

2.08 MANHOLE, VAULT AND PULLBOX RACKING AND SUPPORT

A. General:

1. Install manhole, vault and pullbox cable racks before installing cable.

2. Install racking and cable in such a way to minimize interference with follow-on work. Do not block access to unused conduit.

B. Provide cable racks in every vault/manhole where they are missing or insufficient. Cable racks must meet the following requirements:

1. For use in underground applications

2. Corrosion resistant made from hot dip galvanized steel

3. Use Stainless steel anchoring hardware

C. Cables pulled through CSD manholes must be properly secured to brackets or hooks, which must be installed on "C" channel inserts, furnished by the Civil Contractor.

D. Support: Provide any additional cable support necessary to properly dress and support cable when installing on manhole or pullbox walls and surfaces (e.g., when making 180 degree bends).

E. Supports must be stainless steel, tie wrap attachment of cable and raceways to racking, with cables protected with additional insulation between tie wraps and cables.

PART 3 - EXECUTION

3.01 GENERAL

A. Mandrel all pathways prior to installing cable or pull ropes, whether the pathway is provided by the Contractor or by others, if the Contractor uses the pathway as part of the Contractor installation. Submit mandrel report to VTA and obtain approval, prior to installing cables.

3.02 INNERDUCT INSTALLATION REQUIREMENTS

A. General: Install innerduct in each conduit as indicated on the Contract Drawings and as specified. Where multiple inner duct is required in one conduit, pull all at the same time.

B. 7-Microduct Innerduct:

1. Place 7-Microduct Innerduct in conduit according to manufacturer’s instructions.

2. Trim 7-Microduct Innerduct at the face of the manholes, plug unused cells and seal conduit using conduit seals.

3. Provide adequate slack to push 7-Microduct Innerduct to attach to racks on the sides of vaults/manholes, leaving room for ladders access in center of manhole or vault.

C. Pull Rope: Install pull ropes in unused conduits and innerducts.

3.03 CABLE TRAY

A. Installation: Comply with NFPA 70B.

1. Install cable trays in accordance with equipment manufacturer’s instructions, and with recognized industry practices to ensure that cable tray equipment comply with requirements of NFPA 70, Article 318, applicable portions of NFPA 70B, and NEMA VE 2 for general cable tray installation guidelines.

2. Provide sufficient space encompassing cable trays to permit access for installing and maintaining cables.

3. Cable tray fitting supports must be located such that they meet the strength requirements of straight sections. Install fitting supports per NEMA VE 2 guidelines, or in accordance with manufacturer's instructions.

B. Attachment: Each cable tray section must be attached to the Equipment Room, Communications Room, and Signal House/Rooms ceilings utilizing expansion fasteners appropriate for the ceiling material. Fasteners must be rated for a pull-out load equal to at least 150 percent of the maximum rated load for each cable tray section.

C. Grounding: Cable tray must be grounded to the Equipment Room and Communications Room CMGB utilizing #6 AWG minimum ground wire, per Section 26 05 26, Grounding and Bonding for Electrical systems. In Signal Houses/Rooms, ground the tray to the Signal ground plate. Electrical continuity of the cable tray must be maintained between sections utilizing #6 AWG minimum ground wire and attachment hardware, as recommended by the manufacturer.

D. Signal/Communications Rooms: In Signal/Communications Rooms, install a tray up the side of the wall off to the side of the Signal System terminal board and access doors, to provide support for Communications cable and other cable not being terminated on the Signal terminal boards, up the wall and to facilitate a smooth transition up into the overhead cable tray.

E. Installation of Cable: Cables must be laid into the tray, rather than pulled, wherever possible, so as to eliminate twisting. Cables must be attached to the tray utilizing dielectric ties so as to maintain straight runs and adequate separation of cables. Cables carrying AC and DC power must be separated from audio cables and from data cables. Refer to Section 27 15 00, Communications Low-Voltage Conductors and Cables.

3.04 MANHOLE AND PULLBOX CABLE RACKING INSTALLATION

A. General:

1. Install manhole and pullbox cable racks before installing cable.

2. Install racking and cable in such a way to minimize interference with follow-on work. Do not block access to unused conduit.

3. Cables pulled through CSD manholes must be properly secured to brackets or hooks, which must be installed on "C" channel inserts, furnished by the Civil Contractor. Refer to Section 27 15 00, Communications Low-Voltage Conductors and Cables, for additional requirements.

B. Support: Provide any additional cable support necessary to properly dress and support cable when installing on manhole or pullbox walls and surfaces (e.g., when making 180 degree bends).

C. Install a minimum of 50 ft. of fiber optic cable in each vault or pull box for future extension, unless installed within microduct.

3.05 CABLE TRAY TESTING

A. Factory Tests: Manufacturer must provide test reports witnessed by an independent testing laboratory of the "worst case" loading conditions outlined in these technical specifications and performed in accordance with the latest revision of NEMA VE 1.

B. Acceptance Test: Test cable trays to ensure electrical continuity of bonding and grounding connections, and to demonstrate compliance with specified maximum grounding resistance, in accordance with NFPA 70B, Chapter 18, for testing and test methods. Submit grounding tests results per the requirements of Section 26 05 26, "Grounding and Bonding for Electrical systems."

3.06 FIELD QUALITY CONTROL

A. Quality: The quality of the systems installation must be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with these technical specifications.

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SECTION 27 11 16

COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes the requirements for furnishing and installing racks, cabinets, enclosures, and cable management for Communications equipment at the following locations:

1. VTA Rail Operations Facility (VROP) central Equipment Room.
2. Signals/Communications Rooms at stations.
3. Information Technology Rooms at stations.
4. Intrusion Detection System Cabinets.
5. Intermediate Distribution Frame enclosures.
6. Elevator/SCADA Interface Cabinets.
7. Communications Cabinets at locations designated on the Contract Drawings.
8. Miscellaneous equipment enclosures at locations designated on the Contract Drawings.

1.02 RELATED SECTIONS

A. Section 27 05 00, Common Work Results for Communications

B. Section 27 05 28, Pathways for Communications Systems

C. Section 27 11 19, Communications Terminal Blocks and Patch Panels

D. Section 27 13 00, Communications Network Cabling

E. Section 27 15 00, Communications Low-Voltage Conductors and Cables

F. Section 27 21 00, Communications Network Equipment

G. Section 27 26 00, Communications Programming and Integration Services

H. Section 27 30 00, Telephone System

I. Section 27 42 19, Public Address System

J. Section 27 42 20, Passenger Information Monitor System

K. Section 28 20 00, Video Surveillance (CCTV)

L. Section 28 31 00, Intrusion Detection System (IDS)

M. Section 28 40 00, SCADA Monitoring and Control System

N. Section 34 54 00, Automated Fare Collection System

1.03 REFERENCED STANDARDS

A. The latest versions of the following standards and references apply to the work included in this Section, in addition to those codes and standards common to all communications subsystems specified in section 27 05 00 “Common Work Results for Communications”. If a conflict must arise between various standards, the California state code amendments must govern, or the most strict/conservative requirement must govern.

B. American National Standards Institute (ANSI):

1. Z55.1 Gray Finishes for Industrial Apparatus and Equipment.

C. American Railway Engineering and Maintenance of Way Association (AREMA):

1. Part 2.4.30 Recommended Instructions for Painting.
2. Part 14.1.5 Recommended Design Criteria for Molded Terminal Blocks.

D. American Society for Testing and Materials (ASTM):

1. A48 Standard Specification for Gray Iron Castings.
2. A153/A153M Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

E. California Building Code (CBC):

1. Title 24 Division III, Earthquake Design.

F. California Electrical Code (CEC)

G. Electronic Industries Association (EIA):

1. 310-D Cabinets, Racks, Panels, and Associated Equipment.

H. Federal Railroad Administration (FRA), Code of Federal Regulations.

I. National Fire Protection Association (NFPA):

1. 70 National Electrical Code.

J. Telcordia Technologies:

1. GR-63 Network Equipment-Building System (NEBS): Physical Protection.

1.04 DELIVERY, STORAGE AND HANDLING

A. Delivery: Deliver material and components carefully to avoid breakage, denting and scoring finishes. Do not install damaged equipment.

B. Storage: Store materials in original containers and cartons and in clean dry space, and protect from weather and construction traffic.

1.05 QUALITY ASSURANCE

A. Codes and Standards: Products must be manufactured and installed in accordance with the referenced standards, along with all applicable federal, state and local requirements.

1.06 DEFINITIONS

A. Factory Acceptance Tests: Tests performed at the Contractor's facilities before shipment to verify compliance with the technical specifications and quality standards.

B. Field Acceptance Tests: On-site field tests which exercise each system function through its required operations, including the imposition of simulated conditions, to prove that the installation complies with specified requirements.

C. Operational Testing: On-site tests performed to verify that the all components, equipment, subsystems, and interfaces to other systems, function safely and properly with each other.

1.07 SUBMITTALS

A. Communications Cabinets, Racks, and Miscellaneous Enclosures:

1. Submit manufacturer's catalog data for all proposed materials, with installation recommendations, as part of the Preliminary Design Review (PDR) material.

2. As part of the PDR, address thermal management, including thermal calculation for heat load, heat dissipation, use of heat sinks, fans, air conditioning. Provide complete thermal calculation model for each enclosure type, under the specified maximum ambient conditions.

3. Submit drawings showing the installation details of Communications racks and cabinets for the respective subsystem as part of the Final Design Review (FDR) material. As part of the FDR package submitted for each particular subsystem or location, include updated versions of the information submitted for the PDR and include the details of connections, terminations and access points.

4. Before installation, submit complete installation drawings and procedures, as well as inspection procedures.

B. Test Reports: Submit test reports verifying compliance with testing requirements, per the requirements of Section 01 43 26, Testing and Inspection Agency Qualifications.

1.08 MEASUREMENT AND PAYMENT

A. Measurement: Common Work Results for Communications must be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Common Work Results for Communications must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in this Section complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by VTA, and no additional compensation must be allowed therefore.

PART 2 - PRODUCTS

2.01 COMMUNICATIONS EQUIPMENT CABINETS

A. Design:

1. Equipment cabinets are above ground, pad or pole mounted enclosures sized to house communications equipment ranging from active electronic and optical systems to passive mechanical cross-connect and splicing fields. These cabinets must provide mechanical and environmental protection for the equipment contained within, allow craftsperson work activities and discourage access by unauthorized persons.

2. Means must be provided to control internal temperature and humidity of these cabinets.

3. Outdoor Communications Cabinets must be air-conditioned similar to the existing communications cabinets found on the VTA LRT Tasman East/Capitol Extension. BTU/thermal calculations are required by the Contractor to properly size the air-conditioning units.

B. Construction: The materials and construction must be as follows:

1. Cabinets must be all stainless steel NEMA 4X for sealed cabinets with air conditioning

2. Cabinets must be all stainless steel NEMA 3R for ventilated cabinets without air conditioning, but shall include ventilation including fans as required.

3. Materials shall be of the following minimum gauges:

   a. 1.90 mm (14 gauge) or heavier stainless steel frame.

   b. 1.52 mm (16 gauge) or heavier stainless steel panels.

   c. 1.52 mm (16 gauge) or heavier stainless steel struts.

4. Finish: Cabinet must not be painted on the exterior. Interior, including backboards, must be white color.

C. Safety:

1. The cabinet must be free of defects, such as sharp edges or burrs that could present a safety hazard to personnel involved in their assembly, installation, use or maintenance.

2. Product integrity must be maintained and there must be no deviations from physical criteria that may or will adversely affect the product with respect to safety, reliability, interchangeability, life, performance and operation, and maintenance.

D. Electromagnetic Interference (EMI): Cabinets must be designed for EMI shielding with the following features:

1. Continuously welded seams.

2. Gasketed front and rear doors.

3. Screened ventilation openings if openings allowed for the particular cabinet (NEMA 3R).

4. Tested per MIL-STD-285.

E. Cabinet Interface with Concrete Pad:

1. All cabinets must have a hole pattern on a flat horizontal surface on the base of the cabinet for anchoring to station utility pads. The hole pattern must permit lateral relocation of the fasteners to avoid interference with imbedded rebar. Access to the anchoring hardware is required for verification that hardware continues to meet torque requirements.

2. The concrete pad must slope away from the enclosure, at a minimum ¼" per foot, if the concrete pad is larger than enclosure footprint, coordinate with civil construction.

3. Cabinets must be secured on station utility pad foundations using Hilti Model HSL-3 M12/50 Expansion Anchor or approved equal, seismically rated, to ensure that minimum limits for structural performance meet the requirements and objectives for expansion anchors outlined in Telcordia Technologies GR-63.

F. Cabinet Interface with OCS Poles or TPSS/Signal Case Walls:

G. All cabinets must be equipment without mounting accessories and hardware. The mounting method to OCS poles must be a clamped configuration with galvanized steel straps, without pole penetration; for the TPSS the Communications Interface Cabinet (CIC), this cabinet is provided by the TPSS supplier, communications supplies and installs equipment in the CIC cabinet; for Signal Cases, the equipment is mounted inside the signal case supplied by the signals system, communications provides a separate enclosure inside or outside the signal case as required, for any drilled holes or self tapping screws through the cabinet wall, they must be sealed and waterproofed. Submit proposed mounting details to VTA for approval.

H. Equipment Mounting:

1. Cabinets must include one 483 mm (19 in.), swing-out, aluminum racks with a height as indicated on the Contract Drawings for IDS pole mounts. The racks must have EIA-310-D standard 44 mm (1-3/4 in.) spaced single side drilled; having 12-24 tapped equipment mounting holes.

2. Each cabinet must be furnished with 100 each 12-24 x 16 mm (5/8 in.) pad head machine screws, dog point.

I. SCADA and IT IDS Cabinet Electric Power:

1. Cabinets must be designed to accept station normal power, 208 VAC or 480 VAC, 20 A service to power UPS, which powers the electronic equipment in the rack, in accordance with details shown on the Contract Drawings. Two 120 V (ac) UPS (A & B) power strips equipped with ground fault interrupter (GFI) protection must be provided. If 480 VAC is utilized for the power supply, provide an external step down transformer (480 VAC to 208/120 VAC) in separate enclosure, preferably mounted above the IDS cabinet.

2. A 120 VAC 15 A single phase auxiliary power strip equipped with ground fault circuit interrupter (GFCI) protection must be provided and wired to the IDS UPS as well.

3. A decal showing an electrical schematic of the power wiring must be affixed to the inside surface of the cabinet.

4. A 120 VAC 20 A single phase breaker shall supply power to the IT IDS cabinet adjacent to SCADA IDS Cabinet.

5. Electrical power distribution must comply with the Contract Drawings.

J. Grounding and Bonding: Cabinets must include two electrically isolated grounding buss bars located at the bottom of the cabinet, and meet grounding requirements in accordance with Section 26 05 26, "Grounding and Bonding for Electrical Systems." and as indicated on the Contract Drawings.

K. Door Restrainers:

1. Cabinet doors must be equipped with a device that restrains the doors in the open position, no more than 95 degrees from the closed position.

2. The door restraints must be self-activating when the doors are opened and must be released manually to close the doors.

3. The door restraints must be capable of resisting the opening and closing forces resulting from wind gusts without mechanical damage or loss of function.

L. Communications Node Cabinet Alarms:

1. Intrusion detection via enclosure door redundant contacts must be provided for each cabinet and must provide intrusion alarm indication to the VROF via the Communications PAC, and the EMSU.

2. A temperature sensor must be provided for each Communications and IT Cabinet. The sensor must cover a temperature range of 4°C to 60°C (40°F to 140°F). The sensor must provide a capability for a maintainer to set a predetermined temperature threshold and provide a closed dry contact output “High Temperature Alarm” when the temperature inside the cabinet reaches that preset value. This alarm indication must be provided to the EMSU and to the VROF via the Communications PAC for purposes of monitoring high temperature alarm points.

3. All alarm sensors must be located between the electronic equipment and the top internal surface of the cabinet.

M. Security:

1. Cabinet must be equipped with forced entry resistant doors with a three-point lock. The door handle must accept a padlock.

2. The locking device must be properly sealed to prevent water intrusion into the cabinet. All keys must be alike and master keys will be provided to the VTA.

N. Sun Screens and Insulation for Outdoor Cabinets

1. Mut be provided for Air Conditioned and Non-Air Conditioned Cabinets.

2. Sun screens must be provided for both air conditioned and non-airconditioned cabinets. Sun screens shall be of the same material and thickness as the enclosure, and shall shield a minimum of the entire top of the cabinet, and 10% of the sides of the cabinet.

3. Cabinets must be screened by mounting the cabinets to prevent sun exposure where possible.

4. Cabinets must be insulated as required to minimize thermal load from outdoor sun exposure, but as a minimum, insulation must place interior to the cabinet, on the underside of the top surface of the cabinet, and for all sides if required to manage temperature within the cabinet.

5. Thermal management for cabinets must result in the interior equipment remaining below operational limits of that equipment.

O. Screens (Non-Air Conditioned Cabinets – NEMA 3R):

1. Cabinet cooling systems, using outside air, should be designed to eliminate the need for replaceable air filters.

2. Screens must be provided to minimize the entrance of dust debris and insects into the cabinet.

3. Screened areas must be covered by louvers, hoods or other means to inhibit the entrance of horizontally driven rain.

4. Cabinet must be designed to effectively drain moisture that may enter through screens.

5. Where used, filters and/or screens must be easily removed for cleaning without, removing fasteners, cover plates or, fan assemblies.

P. Air conditioning:

1. Cabinet cooling systems, must be sealed air conditioning systems, unless the Contractor can demonstrate via modeling and calculation, that the equipment installed is hardened adequately for required environmental conditions, without use of air conditioning.

2. Thermal management and monitoring of cabinet temperatures must be provided for all outdoor and indoor cabinets.

Q. Seals and Gaskets:

1. Door seals and gaskets must be designed to seal effectively against water intrusion, dust, debris and insects.

2. The adhesives used on seals and gaskets must maintain satisfactory adhesive qualities and function after exposure to all temperature, humidity, water exposures outlined in the contract documents.

3. Seals and gaskets must be made of a material that has aging characteristics of being highly resistant to heat, ozone and ultraviolet light. Seal material must also be tear resistant, have low compression set in the designed use, and be resistant to such chemical sprays, such as insecticides and repellants.

R. Acoustical Noise Suppression: Cabinets must suppress acoustical noise to a level of 60 dBA at a distance of 1500 mm (5 ft.) from the cabinet during times of maximum noise generation within the cabinet.

S. Lifting Details:

1. Cabinets must be provided with a means such as eyebolts for attaching hoisting lines.

2. Eyebolts used for lifting must not protrude through the cabinet housing and into the interior of the cabinet.

T. Condensation:

1. Cabinets must be designed and must include facilities to prevent condensation within the cabinet.

2. Sealed NEMA 4X cabinets are not allowed in an outdoor environment, if there is no source of interior heat from equipment. NEMA 3R cabinets must be used outdoors if the cabinets do not contain heat producing equipment.

3. Instructions and procedures must be provided to prevent the formation and condensation on installed telecommunications equipment before turn-up and when the equipment is in operation. These procedures must be agreed to by VTA and documented in the cabinet installation and maintenance practices.

U. Documentation:

1. Documentation must be provided with the cabinet, providing as a minimum:

   a. Installation procedures.

   b. Maintenance and repair procedures.

   c. Safety instructions.

2. Cabinets must be provided with decals on the door interior containing information on the equipment system, internal cabling and powering schematics.

3. Cabinets must be provided with a data pocket on the inside of the front door able to hold several 230 mm x 300 mm (9 in. x 12 in.) laminated sheets.

2.02 COMMUNICATIONS EQUIPMENT RACKS

A. Construction:

1. Rack types must be 4 post, 36” deep racks, with an additional separate 6” cable management compartment, along with rack top penetrations and built in cable tray at the top of the rack. Side panels must be solid and removable. Doors must be screened/ventilated. The rack must be APC Netshelter or approved equal.

2. Rack type equipment framework assemblies must not be greater than 2.3 m (7.5 ft.) in vertical height; and must include all necessary hardware for fastening to concrete flooring (or steel flooring, as described herein). Rack frameworks must be of the same height.

3. All framework and concrete expansion anchors (where used) must meet the requirements and objectives outlined in Telcordia Technologies GR-63, and be certified for Earthquake Risk to ensure that minimum limits for structural performance are met.

4. Rack type equipment frameworks should be of 3.04 mm (11 gage) thick welded steel construction whereby all components comprising the framework structure are welded together to form an integral assembly.

5. The uprights of rack type framework assemblies must have EIA-310-D standard 32 mm (1-1/4 in.), 13 mm (1/2 in.) spaced for 44 mm (1-3/4 in.) panels, 12-24 tapped. The hole pattern must accommodate equipment units having 44 mm x 483 mm (1-3/4 in. x19 in.) or 44 mm x 584 mm (1-3/4 in. x 23 in.), as indicated on the Contract Drawings.

6. The uprights of rack framework assemblies must be able to accommodate and include the attachment of end guards as optional framework hardware assemblies to protect the sides of installed equipment from contact with portable apparatus such as test gear and step ladders.

7. Rack frameworks must be painted ANSI 61 gray.

B. Assembly and Accessories:

1. Assemble racks to form a row, provide insulators in two locations at the top of the racks, connecting the racks, while leaving space to remove side panels of each rack.

2. Provide cable support bars and hardware to protect wiring and cabling from vibration, chafing, and rubbing, and to relieve stress. Construct edges to prevent damage to cabling or wiring. Provide grommets and padded edges whenever cable rounds a metal edge.

3. Provide cable ties to keep bundles of internal and external wiring separate. Implement wire harnessing to provide neat and orderly routing, with wires to each device exclusive and together.

4. Provide terminals and fuse panels on the upper portion of rack for connecting wiring and cabling, and installing fuses. On each equipment rack, provide a minimum of 10 percent spare terminals, complete with hardware, (two spare terminals minimum) for each energy used on the rack, whichever is greater. Fuse panels must meet requirements outlined in Section 27 11 19, "Communications Terminal Blocks and Patch Panels."

5. Each rack must be furnished with 50 each 12-24 x 16 mm (5/8 in.) pad head machine screws, dog point.

6. Each rack must be insulated from the floor, from other racks, and from rebar/reinforcement in the floor, using insulated bushings with stainless steel S316 rack floor anchors.

C. Electric Power:

1. Equipment racks in Communication Rooms and Signal Rooms/Houses/Bungalows must be designed to accept station normal power, 208 VAC, 40 A service to power UPS, which powers the electronic equipment in the racks, in accordance with details shown on the Contract Drawings. Two 120 VAC UPS (A & B) power strips equipped with ground fault circuit interrupter (GFCI) protection must be provided per rack.

2. A 120 VAC auxiliary power strip equipped with ground fault circuit interrupter (GFCI) protection must be provided and wired to the Station Electrical Room 120 VAC, single-phase, 20 A breaker.

3. Electrical power distribution must comply with the Contract Drawings.

D. Grounding and Bonding:

1. Electrically isolate each rack from ground and from each other, and where sharing a location with signals, from the signal racks, to facilitate ground isolation.

2. Contractor must meet grounding requirements outlined in Section 26 05 26, "Grounding and Bonding for Electrical Systems." and on the Contract Drawings.

3. Furnish a bolted-type grounding post with each rack to permit removal of ground wire connection for test.

E. Communications Room, IT Room, Signal Case Alarms:

1. Intrusion detection must be provided for each Communication Room and must provide intrusion alarm indication to the VROF via the Communications PAC.

2. A temperature, humidity, and security sensor must be provided for each Communication Room, and Signal Case as part of the ESMU. The temperature sensor must cover a temperature range of 4°C to 60°C (40°F to 140°F). The sensor must provide a capability for a maintainer to set a predetermined temperature threshold and provide a closed dry contact output "High Temperature Alarm" when the temperature inside the cabinet reaches that preset value. This alarm indication must be provided to the VROF via SNMP or the Communications PAC for purposes of monitoring high temperature alarm points.

3. All temperature alarm sensors must be located between the electronic equipment and the top internal surface of the Communication Room

F. Anchoring:

1. The base of rack type equipment frameworks must have a floor anchoring pattern that provides a primary and an alternate location for anchor bolts in each corner of the frame base. The anchoring hole pattern may be diagonal slots or a combination of horizontal and vertical slots located in each corner of the framework base. The alternate floor locations are used if and when obstructions in building floors are encountered.

2. It must be possible to access the base of rack type framework assemblies to verify floor anchor installation without removing installed equipment units. Access to framework bases should be via removable equipment guard rails, guard boxes, or panels.

3. Equipment rack interface with concrete floor:

a. All equipment racks must have a hole pattern on a flat horizontal surface on the base of the rack for anchoring to building floors. The hole pattern must permit lateral relocation of the fasteners to avoid interference with imbedded rebar. Access to the anchoring hardware is required for verification that hardware continues to meet torque requirements.

b. Racks must be secured on foundation using Hilti Model HSL-3 M12/50 Expansion Anchor or approved equal, seismically rated.

c. Racks must be isolated from the floor and anchor bolts/rods using insulating bushings.

2.03 MISCELLANEOUS COMMUNICATIONS EQUIPMENT ENCLOSURES

A. Application: Enclosures must be provided for fiber or cable slack and termination, PAC equipment, protected terminal blocks, and other data communication equipment including but not limited to: IDS locations (in addition to IDS cabinet described elsewhere in this specification, guideway CCTV, substations, signal cases, station electrical rooms, operator break rooms, station platform Maintenance Telephones (MT), equipment room MT, Elevator Emergency Telephones, ELS, IDF and similar enclosures. Enclosures must be sized appropriately for the equipment contained therein as indicated on the Contract Drawings.

B. Mount enclosures indoors or out of direct sunlight if possible.

C. Enclosure: Each enclosure must be stainless steel NEMA 4X with stainless steel backpanels appropriate for mounting the required equipment and terminal blocks. Cable entrances with bushings must be provided. Enclosures must lock closed with a hasp and padlock. All padlocks must be keyed alike, as directed by the VTA. VTA will consider use of stainless steel NEMA 3R enclosures, as may be requested by the Contractor on a case by case basis, but Contractor remains obligated to provide NEMA 4X enclosures and hardened equipment suitable for use in the specified environmental conditions.

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

A. Installation:

1. Develop installation procedures in accordance with the standards defined in these technical specifications.

2. Perform installations in accordance with the approved installation plans.

3. Prepare foundation bases by installing Seismic rated anchor bolts (where required) to a depth of at least 100 mm (4 in.).

B. Inspections:

1. Inspect foundations provided by others and report deficiencies to the VTA. Provide acceptance documentation as specified.

2. Inspect installed cabinets to ensure they are level, plumb and grounded.

3.02 OUTDOOR COMMUNICATIONS CABINET INSTALLATION

A. Sealant: Contractor must seal the base of the cabinet to prevent entry of moisture and dust. The sealing compound must have an expected lifetime of at least 25 years.

B. Seismic:

1. Contractor must follow seismic anchor bolt installation procedure, in accordance with manufacturer's instructions and as specified on the Contract Drawings.

2. Racks must be secured on foundation using Hilti Model HSL-3 M12/50 Expansion Anchor or approved equal, that is seismically rated for this location.

C. Inspection: Provide at least 1 fully loaded cabinet and rack of each type for the VTA's first article inspection at the factory before assembling all the cabinets for the other locations. The cabinet must be inspected for workmanship, function, accessibility, and thermal management (air conditioning, ventilation, fans, sealed without ventilation or air conditioning as may be applicable).

3.03 COMMUNICATIONS EQUIPMENT RACK INSTALLATION

A. Location: Locate equipment racks at locations indicated on the Contract Drawings and as approved by the VTA.

B. Anchoring:

1. Equipment rack interface with concrete floor:

   a. Contractor must follow anchor bolt installation procedure, in accordance with manufacturer's instructions and as indicated on the Contract Drawings.

   b. Racks must be secured on foundation using Hilti Model HSL-3 M12/50 Expansion Anchor or approved equal, that is seismically rated for this location.

2. Equipment rack interface with Signal Houses/Bungalows:

   a. Equipment racks located at Signal Houses/Bungalows must be anchored to metal floor.

   b. The rack base and anchoring method must provide for a self-supporting equipment rack that can withstand overturning moments caused by cable-pulling or earthquake effects without auxiliary support or bracing from the ceiling or side walls. As a minimum, the floor anchoring must withstand the overturning moment of a (300 lb.) force applied at the top of the rack in a horizontal direction, with deflection limited to 1/8”.

C. Grounding: Equipment racks must be grounded in accordance with Section 26 05 26, "Grounding and Bonding for Electrical Systems." and on the Contract Drawings.

3.04 MISCELLANEOUS EQUIPMENT ENCLOSURES

A. General: Contractor must install new miscellaneous equipment enclosures at locations specified in this Section and on the Contract Drawings.

3.05 CSD AND GUIDEWAY CABLE TROUGH INTERFACE

A. General: Make all modifications necessary to existing conduit stub-ups, including extensions and relocations to complete the interface between the cabinets and other communications equipment to the CSD and Guideway Cable Trough. Refer to Section 27 05 28, “Pathways for Communications Systems” for additional requirements.

3.06 TESTING REQUIREMENTS

A. Cabinets and Racks:

1. Rack equipment for the Communications Room/Cabinet, and indoor and outdoor cabinets must be tested on a component by component basis, with a full test performed after installation at the job site, including power supply, thermal management, complete functionality, and integration with all systems.

2. Certified test reports must be submitted to the VTA before shipment, showing successful completion of each test, including thermal management.

3. Grounding: Test per the requirements of Section 26 05 26, "Grounding and Bonding for Electrical Systems."

4. Power Distribution: Test per the requirements as specified.

B. Integration Testing: Refer to Section 01 43 26, "Testing and Inspection," for requirements.

3.07 FIELD QUALITY CONTROL

A. Quality: The quality of the Communications Systems installation must be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications.

END OF SECTION

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SECTION 27 11 19

COMMUNICATIONS TERMINAL BLOCKS AND PATCH PANELS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes furnishing and installing terminal blocks and patch panels for the Communications System including but not limited to:

1. Circuit Breakers and Fuses
2. Terminal Strips
3. Protected Entrance Terminals (PET)
4. Protected Terminal Blocks (PTB)
5. Local Distribution Frames (LDF)
6. Intermediate Distribution Frames (IDF)
7. Elevator/SCADA Interface Terminal Strips (ELS)
8. Single-Mode and Multi-Mode Fiber Optic Distribution Panels (Containing Patch Panels and Splice Trays),
9. Single-Mode and Multi-Mode Fiber Breakout Boxes (FBB),
10. Work Area Outlets (WAO) and related components.

1.02 RELATED SECTIONS

A. Section 27 05 00, Common Work Results for Communications

B. Section 27 05 28, Pathways for Communications Systems

C. Section 27 11 16, Communications Cabinets, Racks, Frames and Enclosures

D. Section 27 13 00, Communications Network Cabling

E. Section 27 15 00, Communications Low-Voltage Conductors and Cables

F. Section 27 21 00, Communications Network Equipment

G. Section 27 26 00, Communications Programming and Integration Services

H. Section 27 30 00, Telephone System

I. Section 27 42 19, Public Address System

J. Section 27 42 20, Passenger Information Monitor System

K. Section 28 20 00, Video Surveillance (CCTV)

L. Section 28 31 00, Intrusion Detection System (IDS)

M. Section 28 40 00, SCADA Monitoring and Control System

N. Section 34 54 00, Automated Fare Collection System

1.03 REFERENCED STANDARDS

A. The latest versions of the following standards and references apply to the work included in this Section, in addition to those codes and standards common to all communications subsystems specified in section 27 05 00 "Common Work Results for Communications". If a conflict must arise between various standards, the California state code amendments must govern, or the most strict/conservative requirement must govern.

B. American National Standards Institute (ANSI):

1. TIA-568 — Commercial Building Telecommunications Cabling Standard.

2. TIA-569 — Commercial Building Standard for Telecommunications Pathways and Spaces.

3. TIA-606 — Administration Standard for Telecommunications Infrastructure of Commercial Buildings.

4. TIA-607 — Commercial Building Grounding and Bonding Requirements for Telecommunications.

C. American Society for Testing and Materials (ASTM):

1. B3 — Standard Specification for Soft or Annealed Copper Wire.

D. National Fire Protection Association (NFPA):

1. 70 — National Electrical Code.

E. Underwriters Laboratories Inc. (UL):

1. 497 — Protectors for Paired Conductor Communication Circuits.

2. 969 — Marking and Labeling Systems.

1.04 QUALITY ASSURANCE

A. The following Codes, Regulations, Reference Standards, and Specifications apply to work included in this section:

1. ANSI TIA-568

2. ANSI TIA-569

3. ANSI TIA-606

4. ANSI TIA-607

5. UL 969

1.05 SUBMITTALS

A. Products:

1. Performance data and descriptions of all products must be submitted as part of the Preliminary Design Review submittal package for each subsystem in which they are used. Additionally include: manufacturer model number, UL listing or rating, critical dimensions and mounting arrangement, and replacement parts list.

2. Samples of products must be submitted upon request.

1.06 MEASUREMENT AND PAYMENT

A. Measurement: Common Work Results for Communications must be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Common Work Results for Communications must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in this Section complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by VTA, and no additional compensation must be allowed therefore.

A.

PART 2 - PRODUCTS

2.01 OVERVIEW

2.02 CIRCUIT BREAKERS AND FUSES

A. Fuses and circuit breakers must be of suitable capacities to protect the various pieces of apparatus from the effects of short circuits or overloads. All circuit breakers and fuses required for the equipment and systems must be in accordance with these technical specifications.

B. Fuses must be readily accessible, non-renewable and must be permanently identified adjacent to the fuse. The rating of each fuse must be permanently and clearly marked on each fuse. The circuit breakers and fuses must be the correct size and rating for circuit current interruption and must protect the electrical equipment and circuits from short-term and long-term overloads.

C. In DC branch circuits, where fusing is impractical, a protective resistance unit must be furnished.

2.03 TAGGING FOR CABLES, WIRES AND EQUIPMENT

A. Cables and Wires:

1. Both ends of each cable must be tagged where cables and wires terminate on terminals, punchdown blocks, connectors, etc. Communications cable identifiers must comply with TIA/EIA-606.

2. Cable function, designation, and termination location must be shown.

3. Sleeve type non-metal tags must be used where cable diameter permits.

4. Flat plastic tags must be used for other cables, as follows:

    a. A single hole in the tag must be provided for attachment with a dielectric tie.

    b. Permanent lettering must be used.

B. Equipment:

1. Label with unique identifiers, all terminal blocks, punchdown blocks, copper patch panels, etc. Communications equipment identifiers must comply with TIA/EIA-606.

2. Permanent lettering scheme must be utilized.

3. Labels must be attached with a non-drying adhesive.

2.04 PUNCHDOWN BLOCKS

A. Type:

1. Blocks must be Krone IDC-Type 50-pair punchdown blocks, or approved equivalent. Blocks must be configured with two columns of 25 pairs of two termination clips. Clips must accept #20 AWG through #26 AWG insulated wire, and #18 AWG and #19 AWG bare wire.

2. Clips must be pre-wired to an Amphenol type RJ21X connector socket, or approved equal.

3. Blocks must be equipped with a base, standoff bracket, cover, and bridging clips.

B. Base:

1. The base must be impact resistant plastic.

2. Molded fanning strips must be provided on each side of the split blocks.

3. Permanent numbering must be applied to the fanning strips.

4. A standoff of 50 mm (2 in.) from the mounting surface must be provided.

5. A removable cover with circuit designations permanently applied must be provided.

6. Connector retention screws must be provided.

2.05 TWENTY-FIVE PAIR CONNECTORS

A. Type:

1. Connectors must be Amphenol-type RJ21X, or approved equal, with a self-extinguishing thermoplastic housing.

2. A slide on cover must protect the connector contacts.

3. Retention screws must be provided.

4. Connectors must be non-reversible and must be compatible in design and type (male/female) with the associated receptacles.

B. Connector Contacts:

1. Two rows of 25 contacts must be provided.

2. Contacts must be insulation displacement type, designed to accept #22 AWG and #24 AWG wire.

2.06 INTERNAL WIRE AND CABLE

A. Jacket: All internal wire and cable must be classified and marked per NFPA 70 Article 800 for the intended installation classification.

B. Conductors: Conductors must be soft annealed copper per ASTM B3.

C. Construction:

1. Single or multiple twisted pair cables must have color coded insulation.

2. Cables must be shielded where recommended by EIA standard for data rate, format, and distance.

2.07 CONNECTORIZED PROTECTED ENTRANCE TERMINALS

A. Design:

1. Protected entrance terminals must be used at the input for small gauge signal (communications) Category 6 or low voltage AC/DC power supply circuits using metal cable and entering/exiting a facility (e.g., Communications Rooms and Cabinets, TPSS). Connectorized protected entrance terminals must be used in all applications unless specifically stated otherwise in this Section or on the Contract Drawings.

2. Protected entrance terminals must have a field splice line side connection stub pre-wired to three element (five-pin) protector sockets. The equipment side of the protectors must be connected via RJ21 connectors.

   a. Protected entrance terminals must include an integral splice chamber.

   b. Protected entrance terminals must be provided in 25, 50, and 100-pair sizes as per the application shown on the approved drawings.

B. Protector Sockets: Protector sockets must be UL standard five pin sockets, with two position (normal and detent) design. In the detent position, the protector must be retained, the line side must be disconnected, and the equipment side must be protected. When fully inserted, the line and equipment side of the tip and ring pair must be protected.

2.08 MULTI-PAIR PROTECTED TERMINAL BLOCKS

A. Design: Protected terminal blocks must be used at the input for all large gauge signal (communications) circuits using metal cable and entering/exiting the facility (e.g., Communications Rooms and Cabinets, TPSS).

1. Multi-pair protected terminal blocks must be utilized for applications requiring non-connectorized 25-pair or less terminal blocks, as specified on the Contract Drawings.

2. Types and pair counts for terminal blocks must be as shown on the approved drawings.

3. Terminal blocks must consist of pairs of brass binding posts imbedded in high impact resistant polyurethane.

4. Binding posts must be pre-wired to two-element protector sockets. The ground of all protector sockets must be wired to a common ground terminal.

2.09 MULTI-PAIR TERMINAL BLOCKS (NON-PROTECTED)

A. Design:

1. Types and pair counts for terminal blocks must be as shown on the approved drawings.

2. Terminal blocks must consist of pairs of brass binding posts imbedded in high impact resistant polyurethane.

3. Binding posts must be equipped with two brass nuts and washers. Binding posts must be sized to accept a minimum of three #19 AWG conductors.

2.10 PROTECTOR MODULES

A. Three Element (5-Pin) Protectors: Protectors must be solid state modules with fuses or heat coils specifically designed for lightning protection.

1. Modules must plug into 5-pin protected entrance terminal sockets.

2. Each module must protect both halves of a pair.

3. Protector modules must be UL 497 listed for Primary protection.

4. Modules must have 2 ns to 5 ns response time.

5. Modules must protect for voltages over 230 V(dc).

6. Modules must protect for currents over 80 A.

7. Modules must be rated for Category 6 cable frequencies, even if connected to analog instruments.

B. Two Element Protectors: Protectors must be solid state modules with fuses or heat coils specifically designed for lightning protection.

1. Modules must plug or screw into protected terminal blocks.

2. Protector modules must be UL 497 listed for Primary protection.

3. Modules must have 2 ns to 5 ns response time.

4. Modules must protect for voltages over 230 V(dc).

5. Modules must protect for currents over 80 A.

6. Modules must be rated for Category 6 cable frequencies, even if connected to analog instrument.

2.11 LOCAL DISTRIBUTION FRAMES

A. Communications Node Local Distribution Frame: An LDF must be provided at each Communications Node. Each LDF must consist of the following equipment:

1. A minimum of one 100-pair connectorized protected entrance terminal, each contained within a separate enclosure. Enclosure must have a fully removable cover in order to provide access to protected terminal blocks.

2. A minimum of four Krone IDC-Type 50-pair connectorized terminal blocks utilizing 25 pair connectors, must be provided as cross-connects.

3. Multi-pair protected terminal blocks designed for a minimum of 36-pairs of PA speaker connections, as shown on Contract Drawings.

2.12 MISCELLANEOUS EQUIPMENT ENCLOSURES

A. Application: Enclosures must be provided for fiber slack/termination, for protected terminal blocks, and other data communication equipment located in substations, Signal/Communications Rooms, Operator Facilities, Electrical Rooms and Elevator Equipment Rooms. Enclosures must be sized appropriately for the equipment contained therein as described in Contract Drawings.

B. Enclosure: Each enclosure must be steel NEMA 4X with steel white-painted backpanels appropriate for mounting the required equipment and terminal blocks. Cable entrances with bushings must be provided. Enclosures must lock closed with a hasp and padlock. All padlocks must be keyed alike, as directed by the VTA.

2.13 MULTI-PAIR DISCONNECT MODULE TERMINAL BLOCKS

A. Design: Multi-pair disconnect module terminal blocks must be as manufactured by Krone, Inc. or approved equal. Terminal blocks must provide normally closed two piece (line side and equipment side) insulation displacement contacts in 8- and 50-pair modules, as per the application shown on the approved drawings. Disconnection of the line side from the equipment side must be by insertion of a disconnect plug.

B. Performance:

1. Contacts must accept #20 AWG through #26 AWG insulated conductors.

2. Contact resistance must be less than 1 μΩ.

3. Insulation resistance must be greater than 50 TΩ.

4. Wire retention force must be greater than or equal to 75 percent of wire breaking force.

2.14 DIGITAL PATCH PANEL – SERIAL COMMUNICTIONS

A. Digital patch panel must be provided for data patching between communications equipment. Panel must meet the following specifications:

1. Patching capability to 13 MHz between Communications Line and Equipment.

2. RS-232 compatible through Standard DB25 "D" connectors.

3. RS-530 compatible through connectors.

4. DTE, DCE, and Monitor jacks for each communications channel.

5. Card Cage to fit EIA 310-D 480 mm (19 in.) rack and contain 18 modules.

6. Five 1800 mm (6 ft.) patch cords per 18-module unit.

2.15 TERMINAL BLOCKS – LOW VOLTAGE CABLES

A. Terminal blocks must be DIN-rail mounted, single or two level as required by the application, and meet the following requirements:

1. Wire gauge range: 28 - 12 AWG

2. Current rating: 25 amps

3. Voltage rating: 600 V

4. Terminal width: 5 or 6 mm

5. DIN rail: 35 mm

B. Terminal blocks must be as manufactured by Automation Systems Interconnect, Inc., series ASI1492 or equal.

2.16 WORK AREA OUTLETS (WAO) – FIBER OPTIC

A. Work area outlets must be provided for terminating fiber optic cables within remote enclosures.

B. Work Area Outlet boxes must conform to the following:

1. Surface mount.

2. 6-port or 12-port, to match the quantity of the fiber strands for incoming fiber-optic cables.

3. Maximum dimensions: 100 mm high x 165 mm wide x 28 mm deep (4 in. H x 6.5 in. W x 1.1 in. D).

4. Configured with LC type dual fiber adapter bezel, each bezel having 1 duplex LC fiber adapter.

PART 3 - EXECUTION

3.01 TAGS

A. All tags must be installed so that they are clearly legible in the normal position. Nomenclature on tags, as installed must not read upside down.

B. All terminal block and apparatus tags must be mounted such that removal of outside wiring from the unit must not require or cause removal of the tag.

3.02 TWENTY-FIVE PAIR CONNECTORS

A. Cable Attachment Tool: 25 pair connectors that are attached to cables in the field must be made-up utilizing a connector attachment tool approved by the manufacturer.

B. Testing: All 25 pair connectors that are attached in the field must be tested, utilizing an approved tester that detects opens, shorts and crosses. Color code must also be verified.

3.03 TERMINAL BLOCKS

A. All connections to terminal blocks must be made in accordance with the approved connection details. Twisted pair jumper wire must be utilized for cross-connections.

B. All wiring on terminal blocks must be neatly bundled, and restrained to facilitate tracing wires by pulling.

C. Tags and labels must be utilized to identify the terminal block designation and the pair number terminated on each terminal.

D. Protected terminal blocks and protected entrance terminals must be grounded with #6 AWG minimum ground wire.

E. All protector modules must be tested prior to installation on terminal blocks.

3.04 DISTRIBUTION FRAME INSTALLATION

A. Mounting: Local Distribution Frames and miscellaneous equipment enclosures must be mounted against walls within the VROF Equipment Room, Communications Room, Communications Cabinets, and other facilities as shown on the Contract Drawings, in locations as approved by the VTA. Hardware used for attachment to walls must be appropriate for the wall material and enclosure load.

B. Wiring:

1. The main/local distribution frame must be wired in accordance with the approved cross-connect Contract Drawings.

2. Tags and labels must be utilized to identify the cross-connect module designation and the pair number terminated on each quick-clip. All tag and label designations must be transferred to the as-built drawings.

3. Cables and cross-connect wiring must be neatly bundled and restrained using dielectric ties in order to facilitate tracing wires by pulling.

4. Distribution frame racks and protected terminal block ground wires must be grounded CMGB (or earth ground busbar) with #6 AWG minimum ground wire.

3.05 WORK AREA OUTLETS

A. WAOs must be mounted within each TVM, PIM, TPSS and IDS cabinet. The WAO must also be used within a stand-alone signal case or a signal cabinet to facilitate fiber-optic communications between the signal equipment and the SCADA equipment.

B. WAOs must be installed per manufacturer's instructions. Locations and mounting details must be provided for to the VTA for review and approval prior to installation.

3.06 FIELD QUALITY CONTROL

A. Quality: The quality of the Communications System installation must be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications and workmanship standards and practices.

END OF SECTION

SECTION 27 13 00

COMMUNICATIONS NETWORK CABLING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes the requirements of the Communications Network Cabling. The Communications Network Cabling provides data and voice cable communications links between the office terminal equipment at the VTA Rail Operations Facility and field terminal equipment at Communication/Signal Rooms and Information Technology Rooms at stations.

B. This Section includes requirements for data and voice communications links between station communications/signal/IT rooms and field locations including, Intrusion Detection System Cabinets, Intermediate Distribution Frame Enclosures, Elevator/SCADA Interface Cabinets, Traction Power Substation SCADA, IT Device Enclosures, and Miscellaneous equipment enclosures at locations designated on the Contract Drawings.

C. This Section includes requirements Fiber Optic Cable links for Transfer Trip functionality between Traction Power Substations #28, #33 and #34.

D. This Section includes requirements for Fiber Optic Cable links for Vital/Non-Vital Signal Networks between stations including, Alum Rock Signal Bungalow, Story and Eastridge Station Signal Rooms.

E. This Section includes requirements for fiber optic cable links from signal rooms at stations to signal cases along the alignment, for Vital and Non-Vital Signal Networks.

F. This Section includes requirements for fiber optic cables, fiber optic fan-out cables, fiber jumpers, and connectors.

1. Single mode and multimode fiber optic cables
2. Fiber optic patch cords and pigtail cables
3. Fiber optic distribution panels
4. Fiber optic patch panels
5. Category 6 cables
6. Category 6 patch cords
7. Category 6 patch panels

1.02 RELATED SECTIONS

A. Section 6.6.2, Submittal, of the Special Conditions

B. Section 01 43 26, Initial Start-up Testing and Inspecting

C. Section 27 05 00, Common Work Results for Communications

D. Section 27 05 28, Pathways for Communications Systems

E. Section 27 11 16, Communications Cabinets, Racks, Frames and Enclosures

F. Section 27 11 19, Communications Terminal Blocks and Patch Panels

G. Section 27 15 00, Communications Low-Voltage Conductors and Cables

H. Section 27 21 00, Communications Network Equipment

I. Section 27 26 00,Communications Programming and Integration Services

J. Section 27 30 00, Telephone System

K. Section 27 42 19, Public Address System

L. Section 27 42 20, Passenger Information Monitor System

M. Section 28 20 00, Video Surveillance (CCTV)

N. Section 28 31 00, Intrusion Detection System (IDS)

O. Section 28 40 00, SCADA Monitoring and Control System

P. Section 34 54 00, Automated Fare Collection System

1.03 REFERENCES

A. The latest versions of the following standards and references apply to the work included in this Section, in addition to those codes and standards common to all communications subsystems specified in section 27 05 00 “Common Work Results for Communications”. If a conflict must arise between various standards, the California state code amendments must govern, or the most strict/conservative requirement must govern.

B. American Society for Testing and Materials (ASTM):

1. ASTM E662 Test Method for Specific Optical Density of Smoke Generated by Solid Materials

C. California Code of Regulations (CCR):

1. CCR Title 24, Part 3 California Electrical Code

D. Electronics Industries Association (EIA)//Telecommunication Industry Association (TIA):

1. EIA 359-A Colors for Color Identification and Coding

2. TIA/EIA-455-B Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components

3. TIA/EIA -455-3-B FOTP-3 Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components

4. TIA-455-13-A FOTP-13 Visual and Mechanical Inspection of Fiber Optic Components, Cables, Devices, and assemblies

5. TIA/EIA-455-25-C FOTP-25 Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies

6. TIA/EIA-455-30-B FOTP-30 Frequency Domain Measurement of Multimode Optical Fiber Information Transmission Capacity

7. TIA/EIA-455-41-A FOTP-41 Compressive Loading Resistance of Fiber Optic Cables

8. TIA/EIA-455-47 FOTP-47 Output Far Field Radiation Pattern Measurement

9. TIA/EIA-455-51-A FOTP-51 Pulse Distortion Measurement of Multimode Glass Optical Fiber Information Transmission Capacity

10. TIA/EIA-455-59 FOTP-59 Measurement of Fiber Point Defects Using an OTDR

11. TIA/EIA-455-61-A FOTP-61 Measurement of Fiber or Cable Attenuation Using an OTDR

12. TIA/EIA 455-88 FOTP-88 Fiber Optic Cable Bend Test

13. TIA-455-91 FOTP-91 Fiber Optic Cable Twist-Bend Test

14. TIA 455-104-A FOTP-104 Fiber Optic Cable Cyclic Flexing Test

15. TIA 455-171-A FOTP-171 Attenuation by Substitution Measurement - for Short-Length Multimode Graded-Index and Single-Mode Optical Fiber Cable Assemblies

16. TIA-568-C.0 Generic Telecommunications Cabling for Customer Premises

17. TIA-568.C1 Commercial Building Telecommunications Cabling Standard

18. TIA-568-C.2 Balanced Twisted-Pair Telecommunications Cabling and Components Standards

19. TIA-568-C.3 Optical Fiber Cabling Components Standard

20. TIA-568-C.4 Broadband Coaxial Cabling and Components Standard

21. TIA-598-C Optical Fiber Cable Color Coding

22. TIA-569 Telecommunications Pathways and Spaces

23. TIA-606-B Administration Standard for Commercial Telecommunications Infrastructure

24. TIA-607-B Telecommunications Grounding (Earthing) and Bonding for Customer Premises

25. TIA-4720000-A Generic Specification for Fiber Optic Cable

26. TIA-1096-A Connector Requirements for Connection of Terminal Equipment to the Telephone Network

E. Insulated Cable Engineers Association, Inc. (ICEA):

1. ICEA S-84-608 Telecommunications Cable Filled, Polyolefin Insulated, Copper Conductor Technical Requirements

2. ICEA S-104-696 Standard for Indoor-Outdoor Optical Fiber Cable

F. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE 383 — Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations

G. International Electrotechnical Commission (IEC):

1. IEC 60332-3 — Tests on Electrical Cables Under Fire Conditions

H. National Electrical Manufacturers Association (NEMA):

1. NEMA WC70 — Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy

I. National Fire Protection Association (NFPA):

1. NFPA 258 — Standard Research Test Method for Determining Smoke Generation of Solid Materials

J. Open DeviceNet Vendors Association (ODVA):

1. The Specification for DeviceNet™

K. Rural Utilities Service (RUS):

1. REA Bulletin 1753F-205 — REA Specification for Filled Telephone Cables (PE-39)

L. Underwriters Laboratories Inc. (UL):

1. UL 758 — Appliance Wiring Material
2. UL 854 — Service-Entrance Cables
3. UL 1581 — Electrical Wires, Cables, and Flexible Cords
4. UL 1666 — Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
5. UL 1685 — Vertical-Tray Fire-Protection and Smoke-Release Test for Electrical and Optical-Fiber Cables

M. U.K. Naval Engineering Standard (NES):

1. NES 711 — Determination of the Smoke Index of Products of Combustion from Small Specimens of Materials
2. NES 713 — Determination of the Toxicity Index of Products of Combination From Small Specimens of Materials

1.04 QUALITY ASSURANCE

A. Qualifications:

1. All wire and cable manufactures must be approved by VTA. The Contractor must provide all data required for the VTA's evaluation and must make the arrangements for any required demonstrations and tests.
2. Qualifications must be based on the following criteria:

a. Past Performance and Experience. The cable manufacturer(s) must demonstrate previous successful experience in supplying wire and cable specified herein. A list of such installations must be provided for each cable manufacturer to be considered.

b. Quality Assurance Program. The manufacturer(s) of cables, in accordance with the requirements of these Specifications, is required to have in place or implement, an effective quality assurance program adhering to the requirements of ISO 9001 to ensure purchase control performance. VTA reserves the right to audit the manufacturer's facilities for conformance to the contract. This may include, but is not limited to first article inspections, source inspections, and on-site surveys. Such compliance must promote a thoroughly tested cable that must render long service life to the user. Prime concern must be focused on the necessary formal assurance requirements to ensure that cable failure cannot be attributed to actions or lack of actions by the manufacturer.

c. Technical Data. The Contractor must provide full technical data that demonstrates compliance with the requirements of these Specifications for each specified cable type the Contractor plans to supply.

d. Demonstration Tests. The Contractor must make arrangements with the prospective cable manufacturer(s) to perform demonstration tests as required by the VTA.

e. Sample Specimens. The Contractor must furnish to the VTA within 20 days after the Notice-to-Proceed, sample specimens in four (4) foot lengths similar to that which the manufacturer(s) proposes to furnish for each type cable specified herein. The sample specimens must remain the property of VTA.

f. The manufacturer(s) must certify compliance with the following warranty prior to selection:

   1) The manufacturer(s) warrants that the design, material, and workmanship incorporated in each item of cable must be of the highest grade and consistent with the established, and generally accepted standards for wire and cable; and that each such item and every part and component thereof must comply with these Specifications.

   2) The manufacturer(s) agrees that this warranty must commence with the acceptance of each item of the cable, whether the defect be patent or latent, and must continue for a period of eight (8) years after initial satisfactory operation of the item or ten (10) years after acceptance of the item, whichever is shorter.

   3) The warranty covering any length of cable that is replaced by the manufacturer(s) under the above conditions must be reinstated for a period of eight (8) years effective as of the day when said replacement is affected. If the failure is found to be of major importance and affects any other item of cable, the reinstatement of the warranty must then be extended to cover the item so affected as well, and must starts as of the date of such replacement. The warranty reinstatement provided for in this subparagraph 3) must apply only to the first replacement or repair of any such item and, in the case of failure of major importance, to the first extension of the said warranty to said affected item.

   4) The foregoing warranty is exclusive and in lieu of all other warranties written, oral, implied, or statutory (except as to title and freedom from lien). In no event must the manufacturer be liable by reason of breach of warranty for special or consequential damages.

3. After Selection of Manufacturer:

a. The Contractor must monitor the manufacturer(s) of the wire and cable to assure that the approved Quality Assurance Program is being closely adhered to and that the wire and cable is being manufactured in accordance with these Specifications and the approved submittals.

b. Each finished wire and cable must be traceable to the test date on file for each step in its manufacturing process.

c. Inspection:

1) VTA, or its authorized representative, must have the right to make such inspection and tests as necessary to determine if the cable meets the requirements of these Specifications. The inspector for VTA must have the right to reject cable that is defective in any respect.

2) VTA must be given fifteen (15) days advance notice of the date the cable must be ready for final testing so that VTA may witness the tests, if it so elects.

3) Physical tests must be made on samples selected at random. Each test sample must be taken from the accessible end of different reels. Each reel selected, and the corresponding sample must be identified. The number and lengths of samples must be as specified under the individual tests. All applicable tests for the cable materials and cable construction specified must be performed.

4) Certified electrical and physical test reports must be furnished for the finished cables no later than the time of shipment. Each test document must, in addition to the test results, indicate the date the tests were performed and the signature of the manufacturer's authorized representative.

5) VTA reserves the right to conduct itself, or by its duly authorized representative, those tests it so elects to further satisfy itself that the cable is manufactured in accordance with the requirements of these Specifications.

1.05 SUBMITTALS

A. Contractor must submit, as part of PDR:

1. For wires and cables and the associated equipment, the following submittals must be provided by the Contractor:

a. Submit manufacturers' catalog cuts, specifications and complete technical information or other data required to demonstrate compliance with these Contract Specifications for each cable or product used, and include as a minimum the following:

1) Purpose and location to be used;

2) Manufacturer of wire and cable, and certificate of compliance;

3) Number and size of strands composing each conductor;

4) Conductor insulation composition type in accordance with California Electrical Code and thickness in mils;

5) Average overall diameter of finished wire and cable;

6) Minimum insulation resistance in megohms per 1000 feet at 86 degrees F ambient;

7) Jacket composition and thickness in mils;

8) Total number of conductors per cable;

9) Shield material (if any) and thickness;

10) Conductor resistance and reactance in ohms per 1000 feet at 77 degrees F ambient; and

11) Conductor ampacity at 86 degrees F ambient for 600 V wire and cable.

12) For fiber optic cables, submit a description of each type and location of splice that will be used, naming the materials, devices, tools, instruments, and other details.

b. Proposed layout, termination and wiring block diagrams for the wire and cable equipment.

c. Optical dB loss calculations for fiber optic cable for each fiber segment starting with the transmitting device and ending with the receiving device including intermediate splices and connections; or, if no devices connected, from Fiber Distribution Panel to Fiber Distribution Panel to include all splices in the fiber segment.

d. Proposed procedures for terminating the cable.

e. Proposed cable splicing procedures.

f. Cable pulling data, including distances and tension calculations, for each segment.

g. Cable pulling equipment and tension monitoring devices.

h. Installation plan, including estimated time for each pull segment; procedures for terminating the cable and preparing for final terminations.

2. Submit manufacturers' catalog cuts, specifications and other data required to demonstrate compliance with these Contract Specifications for the following:

a. Panels, outlets and related hardware

3. Single Mode Fiber Optic Cable:

a. Submit proposed splice locations and associated splice and storage case details for VTA approval prior to ordering single mode fiber optic cable.

B. Contractor must submit, as part of FDR

1. Detailed cable drawings, schematics and equipment and wiring diagrams for each location (e.g. station, Intrusion Detection area, etc.).

2. Two (2) copies of certified factory and field test reports of each length of cable provided and installed with pre-approved test procedures for each test.

C. Test Procedures:

1. Submit factory test procedures per the requirements of Section 27 05 00, Common Work Results for Communications.

2. Prior to testing of the wire, cable and the associated equipment, the Contractor must submit test procedures for the approval by the VTA. As a minimum, the test procedures must meet the testing requirements found in Section 3 below.

D. As-Built Documentation: As part of the As-built documentation, include

1. For each location as-built, drawings of all wire and cable equipment installed and tested under the current project.

2. All witnessed (and signed by VTA) test reports verifying compliance with testing requirements per Section 01 43 26, Initial Start-up Testing and Inspecting, and Section 6.6.2, Submittal, of the Special Conditions.

The VTA reserves the right to request additional submittals than those described herein at no additional cost to VTA.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Provide markings on wire and cable in accordance with applicable NEMA and California Electrical Code requirements. UL listed wire and cable must be labeled with UL listing approval.

B. Ship each unit securely wrapped, packaged, and labeled for safe handling in shipment and to avoid damage.

C. Store wire in a secure and dry storage facility.

D. If fiber optic cable is packaged for shipment, the reels must be non-returnable wooden reels with a maximum reel diameter of 78 inches. The top and bottom ends of the cable must be available for testing. Both ends of each cable must be sealed to prevent ingress of moisture.

1.07 MEASUREMENT AND PAYMENT

A. Measurement: Communications Network Cabling must be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Communications Network Cabling must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in this Section complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

A. General: The existing Cable Transmission System (CTS) provides data and voice communications links between the field terminal equipment at Communications Cabinets, Communication Rooms, TPSSs, and the office terminal equipment at the Younger Maintenance Facility.

B. System Expansion: Under the current contract, the Contractor must furnish and install all wires and cables, cable splices, cable connectors, and other accessories as referenced, but not specified in related Sections and as indicated on the Contract Drawings to facilitate communication interfaces for the station and wayside equipment for the 2 new VTA LRT stations.

C. Network Topology:

1. Physical (Cable) Topology: The optical cable network must consist of the following segments:

a. Two 144 strand single mode fiber optic cable runs from the fiber distribution panel at the Alum Rock station to the fiber distribution panel at the Eastridge Station with cable connections at Story Road Station Signal and Communications Room FDP. Both 144 fiber backbone cables run in a 7 cell microduct which serves as the backbone network. One of the 144 fiber cables is for VTA SCADA Department purposes maintained by Way/Power/Signal staff, and the other 144 fiber is for Information Technology/Fare Collection/Administrative purposes, maintained by IT/Technology staff.

b. Twelve strand single mode fiber optic cables run from each passenger stations to TPSS, SCADA IDS, IT/Tech IDS, and Signal Cases.

c. Twelve strand single mode fiber optic cables run from Alum Rock station to IDS Cabinet #1, from Story Road station to IDS Cabinets #2 and #3 and from Eastridge station to IDS Cabinet #4.

d. Twelve strand single or multi mode fiber optic cable runs between the Station Communication Room and the Intermediate Distribution Frames throughout the stations to service communications equipment (e.g. PIM, TVM, CCTV, Elevator, etc.) as shown on the Contract Drawings.

D. Logical Topology:

1. The two 144 strand single mode fiber optic cables must serve as primary means of communications between the station communication nodes and the VTA central communications' head-end equipment at the YMF and River Oaks Facility. To facilitate these communications, the Fiber Optic Cable Network must expand the existing 10 Gigabit (Gbps) SCADA self-healing ring 2 and expand the existing IT Gigabit Ethernet Network self-healing Loop E:

a. The Ring 2 architecture must consist of a folded, staggered configuration, as shown in the Contract Drawings, with 10 Gigabit ethernet switches between every other node. Nodes will be connected in the ring as shown in the Contract Drawings. Nodes at OCC and end-of-line stations must be looped back to maintain ring continuity. The Contractor must also configure any node for loop back as required to maintain ring continuity during testing activities.

b. The IT Ethernet Loop E architecture must be implemented in a folded staggered configuration with node connections between every other node similarly to the SCADA Ring 2 above and as shown on the contract drawings.

2. Local distribution cables must be run as radial runs from the Ring 2 and Loop E nodes, utilizing dual uplinks paths for remote IP switches, and single connections for the majority of field devices.

2.02 BACKBONE SINGLE MODE FIBER OPTIC CABLE – MICRODUCT INSTALLATION

A. General:

1. Single mode fiber optic inter-facility cables must be gel-free, indoor/outdoor rated, designed for installation in microduct conduit systems. The fiber optic cable must be Corning MiniXtend, AFL MicroCore, or VTA Approved equal.

2. Single mode cable must meet the requirements of the National Electrical Code (NEC) Section 770.

3. Finished cables must conform to the applicable performance requirements of ICEA S-104-696.

4. Fiber optic cable assemblies, including jacketing and fibers must be certified by the manufacturer to have a minimum life of 25 years.

5. Jacket printing: Each shipping length of cable must be permanently identified by printing on the outer surface of the jacket, at intervals of three feet or less. Information must include count of fibers, fiber type and size, cumulative footage markers, manufacturer's designation, and manufacturer's name.

6. Count of optical fibers in each fiber cable, including fibers reserved for future use and for spares, must be 144 fiber strands per cable.

7. Single mode fiber optic cables must use Corning SMF-28 Ultra glass fibers or VTA Approved equal.

B. Single Mode Fiber Specifications:

1. Type: Single-mode, loose tube
2. Operating wavelength: 1310/1625 nm
3. Attenuation at 1310 nm: 0.32 dB/km, maximum
4. Attenuation at 1383 nm: 0.32 dB/km, maximum
5. Attenuation at 1490 nm: 0.21 dB/km, maximum
6. Attenuation at 1550 nm: 0.18 dB/km, maximum
7. Attenuation at 1625 nm: 0.20 dB/km, maximum
8. Polarization Mode Dispersion Link Design Value: 0.04 ps/√km

C. Cable Construction:

1. Optical fibers must be placed inside a loose buffer tube. The nominal diameter of the buffer tube must be 1.4 mm.

2. Each buffer tube must contain 12 fiber strands. The fibers must not adhere to the inside of the buffer tube. Buffer tubes must be resistant to kinking.

3. Each fiber must be distinguishable by means of color coding in accordance with TIA-598-C. The fibers must be colored with ultraviolet (UV) curable inks.

4. In buffer tubes containing multiple fibers, the colors must be stable across the specified storage and operating temperature range and not subject to fading or smearing onto each other. Colors must not cause fibers to stick together.

5. The central member must consist of a dielectric, glass reinforced plastic (GRP) rod to prevent buckling of the cable. The GRP rod must be coated with a thermoplastic to achieve dimensional sizing to accommodate buffer tubes/fillers.

6. The tensile strength must be at least 78 lbf.

7. The jacket must be continuous, free from pinholes, splits, blisters, or other imperfections. The jacket must have a consistent, uniform thickness. The jacket must provide the cable with a tough, flexible, protective coating, able to withstand the stresses expected in normal installation and service.

2.03 OUTSIDE PLANT ARMORED FIBER OPTIC CABLE – RADIAL RUNS

A. Outdoor fiber optic-cable must meet the below additional requirements:

B. The Contractor must furnish, install, test, and document all rugged outdoor fiber optic cables and related components as required to provide a fully functional outdoor fiber optic cable plant. This cable plant must include the cables, all splices, and splice cases.

C. Rugged outdoor fiber optic cable must be as specified herein and must be used to connect all other locations where the Contractor's design compliant the Contract Documents requires fiber cable to be installed in a conduit type other than microduct, except for the 144 fiber backbone cable laterals from the main ductbank to reach communications houses which must be installed within microtubes and protective innerduct, and that the conventional innerduct with enclosed microduct must be installed within conduit.

D. Rugged outdoor fiber optic cable must meet the below requirements:

1. Meet or exceed the requirements of REA PE-90.

2. Have a dielectric central member. The dielectric member must be overcoated with black colored thermoplastic.

3. Cable must be completely dielectric to provide complete electrical isolation along the length of the cable.

4. Cable must have double black polyethylene jackets separated by water blocking yarns for mechanical protection and armor.

5. Be gel-filled have water-blocking tape to prevent moisture incursion.

6. Have a tensile strength of 600 pounds, minimum.

7. Wherever terminated or spliced be connectorized and supported in a cabinet or splice enclosure.

8. Be designed to be moisture resistant, dust resistant and gas tight.

9. Be installed in loose buffer tube filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel must be free from dirt and foreign matter. The gel must be readily removable with conventional nontoxic solvents.

10. Fibers must be colored with ultraviolet curable inks adhering to color coding of TIA/EIA-598-A.

11. Buffer tube color coding must adhere to TIA/EIA-598-A.

12. Be identical in design and construction, except for color coding.

13. Be optimized for wavelength and attenuation per equipment requirements.

14. Type and structure:

    a. Cores:

        1) Type: Glass, single mode fibers.

        2) Fiber core diameter: 8.3 μm.

        3) Cladding diameter: 125 ±3.0 μm.

        4) Operating wavelength 1310/1550 nm

        5) Attenuation @ 1310 nm: less than 0.5 dB/km nominal.

6) Attenuation @ 1550 nm: less than 0.4 dB/km nominal.

7) Attenuation Uniformity: No point discontinuities greater than 0.2 db at either 1,300 nm or 1,550 nm.

8) Core/cladding concentricity: ≤ 1.0 μm.

9) Cladding Noncircularity : ≤ 1 %.

10) Continuous discontinuity: ≤ .2 dB.

11) Fiber coating diameter: 250 μm.

b. Coating:

1) The fibers must be coated with dual layer acrylate protective coating, the primary layer must be low modulus cured acrylate material preferred. the secondary layer must be tight acrylate coating which can be easily removed for jointing. The coating must be in physical contact with cladding surface.

2) The coated fiber must have a layer of Teflon 7 placed between the dual layer acrylate coating of the optical fiber and the thermoplastic buffer. The diameter of the thermoplastic buffer coating must be 900 ±50µm.

3) Contractor must submit the color code of each fiber with the preliminary submittals and product data sheets.

c. Construction:

1) The cable must be of an armored construction consisting of dual extruded, high-density, high molecular weight polyethylene outer jackets separated by water blocking yarns for mechanical protection and armor. The color must not obscure fiber identification colors. The cable core must be loose tube type construction having flame-retardant and moisture-resistant fillers compatible with the other components. Each fiber must consist of a central glass optical fiber surrounded by a primary polymer buffer with a secondary hard elastomeric polymer buffer up to 900 μm. Non-elastomeric (PVC) materials are not allowed. Cable must be rodent proof.

2) The outer surface of the jacket of each shipping length of cable must be permanently identified by printing on the outer surface of the jacket, at intervals of five feet or less. Information is to include count of fibers, fiber type and size, cumulative footage markers, manufacturer's designation and manufacturer's name.

15. Cable Characteristics: All fibers must be usable fibers and meet the following requirements:

a. Each buffered fiber must be color-coded so as to provide unique and permanently visible identification.

b. Maximum tensile load:

1) Short term: 600 lbf (2700 newtons).

2) Long term: 135 lbf (600 newtons).

c. The inert fillers must be free from dirt and foreign material.

d. No long-term detrimental effect on fiber coating, cable sheath, or material in cable jointing.

e. Each optical fiber must consist of a doped silica core surrounded by a concentric glass cladding. The fiber must be a matched clad design.

16. Ductbank and Conduit:

a. All outside plant fiber optic cables must be installed in existing combined system ductbank or conduit.

17. Innerduct: All outside plant fiber optic cables must be installed in innerduct.

18. Environmental Requirements:

a. Crush resistance: The cable must withstand a minimum compressive load of 50 lbf/in applied uniformly over the length of the compression plate. The cable must be tested in accordance with FOTP-41, "Compressive Loading Resistance of Fiber Optic Cables." While under compressive load, the fibers must not experience an attenuation change greater than 0.6 dB at 1300 nm. After the compressive load is removed, the fibers must not experience an attenuation change greater than 0.4 dB at 1300 nm.

b. Impact Resistance. The cable must withstand a minimum of 20 impact cycles. The cable must be tested in accordance with FOTP-25, "Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies." The fibers must not experience an attenuation change greater than 0.4 dB at 1300 nm.

c. Cyclic Flexing. The cable must withstand 25 mechanical flexing cycles at a rate of 30 ±1 cycles per minute. The cable must be tested in accordance with FOTP-104, "Fiber Optic Cable Cyclic Flexing Test." The fibers must not experience an attenuation change greater than 0.4 dB at 1300 nm.

d. Temperature Range. The storage temperature range for the cable on the original shipping reel must be -40°C to +70°C. The installation/operating temperature range for riser cables must be -20°C to +70°C and for plenum cables must be 0°C to +70°C. Testing must be in accordance with FOTP-3.

19. Identification.

a. Color Coding. The individual fibers must be color coded for identification. The optical fiber color coding must be in accordance with EIA/TIA-598, "Color Coding of Fiber Optic Cables". The coloring material must be stable over the temperature range of the cable, must not be susceptible to migration, and must not affect the transmission characteristics of the optical fibers. Color-coded buffered fibers must not adhere to one another. When fibers are grouped into individual units, each unit must be numbered on the unit jacket for identification. The number must be repeated at regular intervals.

b. Jacket Printing. The outer jacket must be marked with the manufacturer's name or UL file number, date of manufacture, fiber type, flame rating, UL symbol, and sequential length markings every two feet (e.g. COMPANY - 01/2005 -62.5/125 MICRON - Type OFNR - (UL) 00001 FEET). The print color must be black. The printing must be permanent and legible for the life of the cable.

c. Labeling. Identification tags or labels must be provided for each cable. Markers, tags and labels must use indelible ink or etching which must not fade in sunlight, or in duct applications. Markers, tags, and labels must not become brittle or deteriorate for a period of thirty years. Label all termination panels with cable number or pair identifier for cables in accordance with EIA/TIA-606 and as specified. The labeling format must be identified and a complete record must be provided to VTA with the final documentation. Each cable must be identified with type of signal being carried and termination points. Adhesive or similar tags which wrap around the wire/cable are not acceptable.

2.04 MULTIMODE FIBER OPTIC CABLE

A. General:

1. Inside plant, intra-facility cables must be multimode, unless otherwise indicated.

2. Cables must be manufactured in accordance with TIA-455-13, TIA/EIA-455-25, EIA TIA-455-41, TIA/EIA-455-47, EIA TIA-455-59, TIA-455-61, TIA/EIA455-88, TIA-455-91, TIA/EIA-455-104, and EIA455-171.

3. Finished cables must conform to the applicable performance requirements of ICEA S-104-696.

4. Fiber optic cable assemblies, including jacketing and fibers must be certified by the manufacturer to have a minimum life of 25 years.

5. Jacket printing: Each shipping length of cable must be permanently identified by printing on the outer surface of the jacket, at intervals of five feet or less. Information must include count of fibers, fiber type and size, cumulative footage markers, manufacturer's designation, plant name (if applicable), and manufacturer's name or UL file number.

6. Individual fibers must be color coded for identification in accordance with TIA-598-C.

7. Count of optical fibers in each cable run, including fibers reserved for future use and for spares, must be as indicated.

B. Multimode Fiber Specifications:

1. Type: Tight buffered, graded index multimode cables without armor and with an outer jacket rated for plenum or non-plenum duty as applicable.

2. Operating wavelength and Bandwidth: 160 MHz·km at 850 nm and 500 MHz·km at 1300 nm

3. Attenuation at 850 nm: 3.5 dB/km, maximum

4. Attenuation at 1300 nm: 1.00 dB/km, maximum

5. Core diameter: 50 µm plus or minus 3.0 µm optimized for 550 meters

6. Cladding diameter: 125.0 µm plus or minus 2.0 µm

7. Each tube and buffered fiber must be color-coded to provide unique and permanently visible identification, per EIA 359-A.

8. Optical Performance: The attenuation must be measured in accordance with TIA-455-61. The bandwidth must be measured in accordance with TIA-455-30 or EIA/TIA-455-51.

9. Loose Tube Cable Characteristics:

   a. Central strength member must be a glass-fiber-reinforced dielectric material.

   b. Loose tubes must be made of a tough abrasion-resistant material, to provide mechanical and environmental protection for the optical fibers.

   c. Water-blocking compound must be provided within the tubes.

   d. If fillers are required, they must be made of a low-smoke, low-halogen polyolefin compound, containing less than 0.5 percent halogen by weight.

   e. Inner jacket must be made of a low-smoke, low-halogen, cross-linked polyolefin, containing less than 0.5 percent halogen by weight.

10. Tight Buffered Cable Characteristics:

    a. Fibers must be tight buffered to 900 μm diameter, using a tough elastomeric buffer material.

    b. Buffered fibers must be stranded together with dielectric strength members.

    c. Inner cable jacket must be pressure-extruded onto cabled fibers and strength members in the core assembly. This jacket material must be of zero-halogen flame-retardant composition.

11. Outer Jacket Assembly:

    a. Jacket material must be a flame-retardant, low-smoke, low-halogen insulating compound that is ultraviolet (UV) resistant. The outer jacket must be extruded over the shield/armor in a tight-fitting assembly.

    b. A 0.006-inch thick (minimum) corrugated electrolytic chrome coated steel tape, plastic coated on both sides, must be tightly wrapped, around the inner jacket.

    c. A ripcord (or two ripcords) of compatible material must be built into the cable assembly, to facilitate removal of the wrap and jackets during installation.

12. Overall Physical Characteristics of Cable:

    a. Cable design to conform with TIA-4720000-A, and EIA TIA-455-B, including Addenda 455 (1-190), unless indicated otherwise.

    b. Pulling Load (installation): 600 pounds, minimum

    c. Operating Load: 112 pounds, minimum

    d. Resistance to Crush: 700 pounds/inch for 60 seconds

    e. Minimum bending radius: 20 times the outside diameter of the cable

13. Environmental Characteristics:

    a. Completed fiber optic cable of either type must comply with the flame-retardant requirements of IEEE 383.

    b. Cable jacket material (inner and outer jackets) must have specific optical densities of less than 200 in the non-flaming mode and 75 in the flaming mode, when tested per ASTM E662.

c. Cable jacket material (inner and outer jackets) must have a halogen content of less than 0.5 percent by weight.

d. Completed cable, of either type, must have a toxicity index of less than 5.0 in accordance with TIA-455-3.

14. Identification:

a. Color Coding: The individual fibers must be color coded for identification in accordance with TIA-598-C. The coloring material must be stable over the temperature range of the cable, must not be susceptible to migration, and must not affect the transmission characteristics of the optical fibers. Color-coded buffered fibers must not adhere to one another. When fibers are grouped into individual units, each unit must be numbered on the unit jacket for identification. The number must be repeated at regular intervals.

b. Jacket Printing: The outer jacket must be marked with the manufacturer's name or UL file number, date of manufacture, fiber type, flame rating, UL symbol, and sequential length markings every 2 feet (e.g. "COMPANY - 08/17 -50/125 MICRON - Type OFNR - (UL) 00001 FEET"). The print color must be black. The printing must be permanent and legible for the life of the cable.

2.05 OPTICAL CONNECTORS

A. Patch Panel Connectors: Lucent Connector (LC) ultra physical contact (UPC) connector with 126 µm (single mode) or aqua 127 µm (multimode) ceramic zirconia alignment ferrules must be used for fiber patch panels. Connector insertion loss must be nominally 0.3 dB and less than 0.5 dB. LC connectors must be field installable. Dust caps must be provided for all sleeves.

B. Equipment Connectors:

1. Fiber optic connectors must match and be compatible with equipment terminations. Connector insertion loss must be nominally 0.3 dB and less than 0.5 dB. Connectors must be field installable. Dust caps must be provided for all sleeves.

2. Single mode connectors must be a single mode LC connector pair with a duplex clip, a 126 µm ceramic zirconia ferrule, supplied with a white 900 µm for buffered fiber and a 1.6 mm boot with white and yellow shrink sleeves for patch cables.

3. Multimode connectors must be aqua multimode LC connector pair with a duplex clip, a 127 µm ceramic zirconia ferrule, supplied with a white 900 µm for buffered fiber and a 1.6 mm boot with white and yellow shrink sleeves for patch cables.

2.06 FIBER OPTIC PATCH CORDS

A. Fiber optic patch cords must be cable assemblies consisting of flexible optical fiber cables with the same physical and operational characteristics as the parent cable equipped with compatible connectors. Patch cords must be complete assemblies from manufacturer’s standard product lines. Lengths must be as required. Fiber optic patch cords must meet the following requirements:

1. Cable construction must allow a small bend radius for installation in space-constrained areas. The cable must contain a dielectric strength member and a protective outer jacket. The cable jacket color must be orange with the fiber core size identified on the outer jacket.

2. Connector insertion loss must be less than 0.2 dB.

3. Cables must meet the UL 1666 flame test and must be of the Optical Fiber Nonconductive Riser (OFNR) type listed with Underwriters Laboratories. Optical Fiber Nonconductive Plenum (OFNP) cables may be used as a substitute subject to VTA's approval.

4. Fiber optic patch cords must be two-fiber zip cord type with 1.6 mm outside diameter or equal.

5. Fibers must be terminated at each end with connectors as specified herein.

2.07 FIBER OPTIC PIGTAIL CABLES

A. Cables used for connections to equipment must be flexible fiber pigtail cables having the same physical and operational characteristics as the parent cable and meet the following requirements:

1. The cable jacket must be flame retardant Polyvinyl Chloride (PVC) or Fluorinated Ethylene Propylene (FCP) conforming to NFPA 70 for OFNP applications.

2.08 FIBER OPTIC DISTRIBUTION PANELS

A. Fiber distribution panels (FDP) must be complete systems of components by a single manufacturer with termination, splice storage, routing, radius limiting, cable fastening, storage, and cross-connection capabilities and with the following features:

1. Strain relief for cables.

2. Labeled with alphanumeric x-y coordinates and with labeling space.

3. Connectors and couplers of the LC to pigtail modular assemblies.

4. Fully populated with LC connector modules in the quantities required to accommodate the quantity of fibers entering the fiber distribution panel.

B. Provide separate fiber distribution panels for the backbone and field equipment:

1. Backbone fiber distribution panel must accommodate a minimum of 240 LC connectors or include 25 percent spare capacity, whichever is highest.

2. Field equipment fiber distribution panels must accommodate a minimum of 96 LC connectors or include 25 percent spare capacity, whichever is highest.

C. FDPs must be rack mounted or wall mounted as indicated.

2.09 FIBER OPTIC BREAK OUT BOXES

A. Fiber optic break out boxes shall be provided at remote enclosure/cabinet locations, and must be a complete system of components furnished by a single manufacturer, and must provide termination, splice storage, routing, radius limiting, cable fastening, storage, and cross-connection. Patch panels must employ rack-mounted connector housing equipped as follows:

1. Minimum of 12 fibers.

2. Connector panels accommodating 12 fibers with LC connectors.

3. Cable management.

4. Rear or sliding access for terminations.

5. Splice trays with splice protectors.

6. Splice tray holder.

7. Fiber optic patch panels must be ADC TFP series with specified accessories or equal.

B. Fiber optic break out boxes must be the point of entry of all fibers into remote enclosures/cabinets.

2.10 FIBER OPTIC SPLICE AND STORAGE CASES

A. Provide 144 strand fiber indoor splice and storage cases in communication rooms. Cases must be wall mounted and meet the following requirements:

1. Metal construction

2. Lockable

3. Splice tray holder and splice trays for locations where splicing is required

4. Cables strain relief

5. Capacity to storage up to 100 feet of microfiber cable

6. Port designation labels

7. Use LC adapters

8. Indoor splice and storage cases must be Corning IT-WCH-06P or equal

B. Provide 144 strand fiber outdoor splice and storage cases in the combined systems ductbank. Cases must meet the following requirements:

1. Metal construction

2. Lockable

3. Splice tray holder and splice trays for locations where splicing is required

4. Cables strain relief

5. Capacity to storage up to 100 feet of microfiber

6. Port designation labels

7. Use LC adapters for splices

8. Waterproof

2.11 CATEGORY 6 CABLES

A. Unshielded cables must be plenum rated and employ 100 ohm, four balanced, unshielded twisted pairs (UTP). Inter-cabinet tie cables must be UTP, 25, 50 or 100 pair cables as required to meet the active pair count including 50 percent spare pairs. Conductors must be #24 AWG solid copper. Cable insulation jackets must be color coded for the service type: blue for data, white for voice and green for video applications.

B. Shielded cables must be plenum rated with an overall foil tape shield and four balanced, unshielded twisted pairs (F/UTP). Conductors must be #24 AWG solid copper. The shield must be an aluminum foil tape enclosing a 24 AWG tinned copper drain wire. Cable insulation jackets must be color coded for the service type: blue for data, white for voice and green for video applications.

C. Cable jackets must be legibly marked with the following information:

1. Manufacturer’s name
2. Copper conductor gauge
3. Pair count
4. UL or CSA rating
5. Manufacturer’s trademark
6. Category rating, including UTP, F/UTP[ScTP] (screened twisted pair)
7. Sequential foot markings, in one or two foot increments

2.12 CATEGORY 6 PATCH CORDS

A. Unshielded Category 6 patch cords must be rated for 250 MHz or better and must be composed of four, 24 AWG stranded copper conductors with 50-micro-inch (minimum), 24 carat gold plated RJ-45 male to male connectors and a plenum jacket.

B. Shielded Category 6 patch cords must be rated for 250 MHz or better and must be composed of four, 24 AWG stranded copper conductors with shielded 50-micro-inch (minimum), 24 carat gold plated RJ-45 male to male connectors, an overall shield with aluminum foil tape enclosing a 24 AWG tinned copper drain wire, and a plenum jacket.

2.13 CATEGORY 6 PATCH PANELS

A. Category 6 Patch Panel Requirements:

1. Category 6 digital patch panels must have a minimum of 48 ports or 25 percent spare capacity, whichever is higher.
2. Unshielded Category 6 patch panels patch panels must employ a modular design that utilizes jacks installed into each panel position.
3. Unshielded Category 6 jacks supplied with the panel must meet the requirements of TIA-568-C.2. Unshielded Category 6 jacks must also be available with detailed installation instructions.
4. Panel ports must have a rectangular, industry standard keystone opening (0.760-inch x 0.580-inch) with a permanent port identifier number under each opening.

5. Panels must have integral cable management features in front for patch cords and features in the rear for horizontal cable management.

6. Shielded patch panels must have provisions for connection for grounding jumpers from each installed shielded jack.

7. All transmission parameters must be verified by a UL or ETL testing organization. Transmission testing must be to 250 MHz.

8. Unshielded Category 6 panels with unshielded jacks must exceed transmission requirements specified in TIA-568-C (specification limit is 250 MHz).

9. Contractor must ensure that the manufacturer provides compliance certificates from a third party testing organization upon request.

10. Panels must be UL listed 1863 and CSA certified.

11. Panels must exceed IEEE 802.3 DTE power specification to four times the rated current limits with no degradation of performance or materials.

12. Panels must be third party verified to Gigabit Ethernet performance according to IEEE 802.3Z (current draft).

13. Panels must meet or exceed the four-connector channel performance requirements of TIA-568-C.2 standard.

14. Unshielded Category 6 Patch Panels: The four-connector channel test configuration must utilize unshielded Category 6 jacks, patch panels and patch cords, from the same manufacturer, with qualified UTP Category 6 cable.

15. Shielded Category 6 Patch Panels: The four-connector channel test configuration must utilize shielded Category 6 jacks, patch panels and patch cords, from the same manufacturer, with qualified screened (F/UTP[ScTP]), or shielded (STP) Category 6 cable.

16. Category 6 patch panels must be Ortronics Clarity 6 series or equal.

2.14 TERMINAL BLOCKS

A. Terminal blocks must be DIN-rail mounted, single or two level as required by the application, and meet the following requirements:

1. Wire gauge range: 28 - 12 AWG
2. Current rating: 25 amps
3. Voltage rating: 600 V
4. Terminal width: 5 or 6 mm
5. DIN rail: 35 mm

B. Terminal blocks must be as manufactured by Automation Systems Interconnect, Inc., series ASI1492 or equal.

2.15 OUTLETS, HARDWARE, AND CONNECTIONS

A. Work Area Outlets (WAOs): WAOs must be Category 6 Keystone jacks with universal wiring (TIA-568A/B) mounted in single or dual port faceplates as required when within TIA-568C.1 length specifications.

2.16 LOW SMOKE ZERO HALOGEN CABLE PROPERTIES

A. Cables used in the Communications Equipment Rooms must have low smoke, zero halogen properties.

PART 3 - EXECUTION

3.01 PRODUCT DELIVERY, HANDLING AND STORAGE

A. Packing:

1. All optical cable drum barrels must not be less than twenty (20) times the finished cable nominal diameter and must in no case be less than the minimum bending radius. The following particulars must be stenciled or painted in a permanent manner on the outside of the flange of each drum. Wherever necessary, the whole of the outside of the flange of the drum must be painted over to cover all marks having no reference to this Contract.

    a. The words “Optical Fiber Cable”.

    b. The manufacturer’s identification of the cable type and date of manufacture.

    c. Gross weight of Reel and Cable.

    d. Full description of the cable including the number of fibers.

    e. Cable identification number which is uniquely referenced to test sheet.

    f. Length of Cable.

    g. An arrow showing the direction in which the drum should be rolled to gain access to the cable.

    h. All ends of the cable must be sealed to prevent entrance of moisture.

2. Wire and cable provided for communications must be shipped in cartons or in coils. The wire must be bound with steel strap and waterproof paper to prevent damage during shipment.

B. Handling – Cable drums must be complete with close fitting wooden battens to prevent damage to the cable during transit and storage.

C. Acceptance at Site – Drums must be examined at Contractor’s local site depot for external damage. Damaged cables must not be accepted.

D. Storage and Protection – Drums must be stored with flanges upright, cable on drums with batten in place must be stored indoors. Open drums must be protected by a waterproof cover.

3.02 INSTALLATION

A. Install cabling in accordance with TIA-568-C and as indicated. Label cabling, distribution panels, terminal blocks, and outlets in accordance with ANSI/TIA-606-B. Secure cables not installed in cable tray and conform to NFPA 70 if installed in plenums or other spaces used for environmental air.

B. Provide wiring complete as indicated. Provide ample slack for field terminated wires and preformed cables with connections.

C. Do not bend copper cables during installation, either permanently or temporarily, to radii less than 12 times the outer diameters, except where conditions make the specified radius impractical and shorter radii are permitted by the California Electrical Code and NEMA WC70, Appendix N.

D. Bundle cable and conductors neatly and securely with nylon straps located in branch circuit panel boards, equipment cabinets and control panels. Use nylon bundling straps; bundle power cables separately from control cables.

E. Fiber Optic Cables: Provide 50 feet of slack in the manholes, pull boxes and walls of communications rooms where OSP fiber optic cable is installed. Provide indoor or outdoor splice and storage cases, as appropriate in each manhole, pull box and communication room.

F. Install fiber optic cables as follows:

1. Install all horizontal and inter-facility fiber optic cables in innerducts. In conduits where at least one innerduct is required, fill the conduits to capacity with innerducts. Provide all unused innerducts with lubricated pull tape or line. Install all inter-cabinet fiber optic cables in the communications equipment room in innerducts.

2. Spare fibers must be secured and supported neatly with Velcro®.

3. Terminate all backbone and horizontal fiber optic cable to maintain manufacturer-recommended bending radii, pulling tension, and cable support requirements. All cables and equipment must be securely and neatly installed. Inside routing must be installed parallel and perpendicular to existing structural lines and members. Plastic or metal cable ties must not be used; only Velcro®, Millipede™, or equal ties are permitted.

G. Fiber optic cable pulling must comply with the following:

1. Pull on the cable strength members only. Do not pull on the jacket unless it is specifically approved by the cable manufacturer and an approved cable grip is used.

2. Do not exceed the maximum pulling load rating. On long runs, use proper lubricants and make sure they are compatible with the cable jacket. If possible, use an automated puller with tension control or at least a breakaway pulling eye.

3. Do not exceed the cable bending radius.

4. Do not twist the cable. Roll the cable off the spool instead of spinning it off the spool end. When laying the cable out for a long pull, use a "Figure 8" on the ground or use a swivel pulling eye to prevent twisting forces on the cable.

5. Verify the cable is long enough for the run before installation.

3.03 CABLE IDENTIFICATION AND LABELING

A. Provide identification tags or labels for each cable. Tags and labels must use indelible ink or etching which must maintain legibility in sunlight or in duct or wet applications. Tags and labels must not become brittle or deteriorate and must be legible for 30 years. Label all termination panels with cable number or pair identifier for cables in accordance with TIA-606-B and as specified. The labeling format must be identified and a complete record must be provided to VTA with Record Drawings (as-built drawings). Each cable must be identified with type of signal being carried and termination points.

B. Affix identification and warning signs to fiber distribution panels, fiber patch panels, terminal equipment, patch cords and fiber optic cables.

C. Provide nonmetallic fiberboard or plastic identification tags or pressure sensitive labels designed for fastening to cables in vaults, pull boxes, manholes and equipment rooms, and at all terminations of cable or wire.

D. If suspended type identification tags are provided, attach the tags to slip-free plastic cable lacing units or to nylon bundling straps.

E. Provide weatherproof warning tags to flag the presence of optical cables. Install such tags on or near optical cables, using distinctive tags to identify the cables, in the following locations:

1. Every 10 feet in communication equipment areas.

2. At each location where optical cables enter or exit raceways of any sort.

3. On exposed conduit runs under station platforms or in plenums, at intervals of 50 feet.

4. At each manhole location along the communications wayside duct bank runs.

3.04 SPLICING AND TERMINATION OF FIBER OPTIC CABLES

A. Make splices in fiber optic cable fibers only inside communication rooms, or in accessible wayside enclosures.

1. All splices, including splices of pigtails to incoming fibers, must be the fusion type. Apply protective covering and coating, made of compatible material, to all completed and tested splices.

2. Contain splices with re-enterable splice modules that are designed specifically to accommodate fiber splices and the prescribed extra lengths of fiber.

3. If splices are not made immediately after cable installation, seal the free ends of such cables as recommended by the manufacturer to prevent entrance of moisture and contaminants.

4. Optical cables must not be spliced along the wayside unless all other options have been explored and found to be technically impractical. Splices along the wayside must be subject to the approval of VTA. Where allowed, make splices in outdoor weatherproof splice enclosures, complete with entry raceways, foundations, mounting hardware, secured access door, and exterior fittings.

5. Equip the interior wayside splice enclosures with fittings designed to organize the cables, splices, and prescribed extra length of fibers. Make provisions to add a renewable desiccant compound to protect against condensation or migration of water.

6. Optical cable termination at communication rooms: Terminate or splice as indicated all fibers at the fiber termination panel within communication room as follows:

a. Terminate incoming optical fibers using matching single-mode optical fiber pigtail assemblies. Splice such fibers to the pigtail assemblies within a splice tray or trays.

b. Assign and terminate incoming and outgoing optical fibers; spares that are designed to pass through the local site must be spliced together within a splice tray or trays where designated splices are configured.

c. Configure terminations to use the least number of splices feasible.

3.05 CATEGORY 6 CABLE AND PATCH CORD INSTALLATION

A. All backbone and horizontal Category 6 cable must be terminated to Keystone style jacks. Maintain manufacturer recommended bending radius, pulling tension, and cable support requirements. All cables, wires, and equipment must be securely and neatly installed. Inside routing must be installed parallel and perpendicular to existing structural lines and members. Plastic or metal cable ties may not be used; only Velcro®, Millipede™, or equal ties may be used.

B. Category 6 data cabling must be terminated in accordance with the TIA/EIA 568B sequence specification.

C. Category 6 patch cords must be terminated in accordance with the TIA/EIA 568B sequence specification.

3.06 CATEGORY 6 PATCH PANEL INSTALLATION

A. Mount patch panels into designated rack or cabinet locations.

B. Keystone jacks are required for Category 6 cable termination. Terminate the shielded or unshielded jacks as applicable and install into the patch panel according to manufacturer's instructions.

C. Cable terminations must have no tensile or bending strain on the installed shielded jacks.

D. Consolidation point equipment, where applicable, must be fully installed and terminated prior to testing.

E. Panels must be labeled on front and back with the cable number and port connections for each port.

F. Shielded Patch Panels: The panel grounding strap must be installed to connect the cable shield and drain wire to the building signal ground in accordance with TIA-607-B.

3.07 LABELING OF TIE CABLES, FIBER AND COPPER CABLES

A. All cables placed in a VTA manhole conduit system must be placed, tagged, and labeled as shown in examples below.

B. Cables must be placed in the same designated conduit end to end.

C. Cables will be labeled at both ends of the feed or lateral manholes.

D. Labels must be waterproof and weatherproof.

E. The labels must have information etched into the label or printed with a waterproof ink.

F. The labels must be durable and designed to maintain adhesion and legibility per the site conditions.

G. Labels must have the following information on the cable labels per the criteria and examples that follow:

1. To Building:

    a. To building name

    b. To building Floor

    c. To building terminal room number

2. From Building:

    a. From building name

    b. From building floor

    c. From building terminal room number

3.08 FACTORY AND FIELD TESTING

A. All Fiber Optic tests must be conducted with the same type of optical source as used in the design.

1. Fiber Optic Cable Factory Tests: Manufacturer's test results and certifications for specified tests must be submitted to VTA for approval before delivery.

    a. Cable must be tested on-reel prior to shipment.

B. Fiber Optic Post-Delivery Inspection and Tests: The following post-delivery tests must be performed with the cable on the reel:

1. Verification and documentation that factory packaging is undamaged and intact.

2. Verification of continuity, attenuation, and absence of anomaly for each reel.

3. End to end loss must be recorded for each single mode fiber at 1310 nm, 1550 nm and 1650 nm.

4. End to end loss must be recorded for each multimode fiber at 850nm, and 1310 nm.

5. OTDR with hardcopy record must be provided for each single mode fiber, at 1310 nm, 1550 and 1650 nm.

6. OTDR with hardcopy record must be provided for each multimode fiber, at 850 nm and 1310 nm.

7. Polarized Modal Dispersion (PMD) for each single mode fiber must be measured using a PMD analyzer and polarized light source.

8. Chromatic optical dispersion must be tested for each single mode fiber.

9. Certified copies of tests results must be submitted to VTA as described in these specifications 14 days after completion of each test before proceeding to the next step.

C. Field Tests: Field tests must include the following tests:

1. Inspection of the appearances of each end of each installed un-spliced cable run.

2. All cabling must be tested as indicated and according to the following requirements:

   a. Conduct an OTDR test after the cables have been installed. Conduct a final OTDR test after fiber optic cables have been terminated and spliced as specified.

   b. Power meter testing shall be conducted for each fiber optic link, end to end, from FDP to FDP or FDP to FBB as applicable, determining optical attenuation, with testing in both directions on each fiber strand, whether terminated or not.

   c. These test results must be documented and submitted to VTA for approval 14 days after completion of each test before proceeding to the next step.

3. Field tests must be performed after installation is complete.

4. One week advance notice to VTA must be provided.

5. Every fiber optic cabling link installed by the Contractor must be tested in accordance with the field test specifications defined by the TIA standard TIA-568-B.1-3.

6. TIA-568-B.1-3, must be used to define the passive cabling network, to include cable, connectors, and splices (if present), between two optical fiber patch panels (connecting hardware). This TIA document must be used to describe all applicable link segments. Tests must include the representative connector performance at the connecting hardware associated with the mating of patch cords but not the performance of the connector at the interface with the test equipment.

7. All of the cabling links installed must be tested and must pass the requirements detailed herein. Any failing link must be diagnosed and corrected prior to the system acceptance. The corrective action must be followed with a new test to prove that the corrected link meets the performance requirements. The final and passing result of the tests for all links must be provided in the test results.

8. Trained technicians who have successfully attended a required training program and have obtained a certificate, as proof thereof must be used to execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:

   a. The manufacturer of the fiber optic cable and/or the fiber optic connectors.

   b. The manufacturer of the test equipment used for the field certification.

   c. Training organizations authorized by BiCSi (Building Industry Consulting Services International with headquarters in Tampa, Florida) or by the ACP (Association of Cabling Professionals™) Cabling Business Institute.

9. The fiber optic launch cables and adapters must be of high quality and the cables must not show excessive wear resulting from repetitive coiling and storing of the test instrument interface adapters.

10. The Pass or Fail condition for the link-under-test is determined by the results of the required individual tests.

11. A Pass or Fail result for each parameter is determined by comparing the measured values with the specified test limits for that parameter.

12. VTA representative must be invited to perform field-testing. The representative must be notified of the start date of the testing phase five business days before testing.

D. Cable Plant Power Meter Test Performance Parameters:

1. In compliance to TIA standard 568-B, the single performance parameter for field-testing of fiber optic links must be link attenuation (insertion loss).

2. The link attenuation must be calculated by the following formulas specified in TIA standard 568-B:

    a. Link Attenuation = Cable Attenuation + Connector Attenuation + Splice Attenuation.

    b. Cable Attenuation (dB) = Attenuation Coefficient (dB/km) x Length (km).

    c. Connector Attenuation (dB) = number of connector pairs x connector loss (dB).

    d. Splice Attenuation (dB) = number of splices (S) x splice loss (dB).

    e. The values for the Attenuation Coefficient are listed below:

        1) Single mode (outside plant), 1310nm: 0.32 dB/km

        2) Single mode (outside plant), 1550nm: 0.18 dB/km

        3) Single mode (outside plant), 1625nm: 0.20 dB/km

        4) Multimode, 850 nm: 3.5 dB/km

        5) Multimode, 1300 nm: 1.0 dB/km

3. Link attenuation must not include any active devices or passive devices other than cable, connectors, and splices, i.e. link attenuation must not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.

4. Test equipment that measures the link length and automatically calculates the link loss based on the above formulas is preferred.

5. The above link test limits attenuation is based on the use of the One Reference Jumper Method specified by TIA-526-7, Method A.1; or the equivalent method. The user must follow the procedures established by these standards or application notes to accurately conduct performance testing.

6. All Multimode cable links must be tested in both directions at the specified operating wavelengths to account for attenuation deltas associated with wavelength.

7. All single mode cable links must be tested in both directions at the specified operating wavelengths to account for attenuation deltas associated with wavelength. All single mode links must be certified with test tools using laser light sources at 1310 nm, 1550 nm and 1625 nm.

E. OTDR Test:

1. All cables must be OTDR tested at specified operating wavelengths for anomalies and to ensure uniformity of cable attenuation and connector insertion loss.

2. OTDR tests must be performed utilizing a pulse suppressor such that the FDP termination must be shown.

3. All OTDR testing procedures and field-test instruments must comply with applicable requirements of:

    a. TIA-455-133-A

    b. TIA-455-78-B

4. Each fiber link and channel must be tested in two directions.

5. A launch cable must be installed between the OTDR and the first link connection.

6. A receive cable must be installed after the last link connection.

7. Optical Return Loss (ORL) for each link must be measured.

8. Fiber Length must be measured.

9. An Optical Spectrum scan of each link must be performed using an optical spectrum analyzer and optical switch to examine fiber nonlinear effects including but limited to Brillouin scattering and four wave mixing across the fiber's usable light spectrum.

10. Polarized Modal Dispersion (PMD) for each link must be measured using a PMD analyzer and polarized light source.

11. Chromatic dispersion test must comply with the following standards:

    a. IEC 60793-1-42 Measurement methods and test procedures—chromatic dispersion

    b. ITU-T G.650.1 Definitions and test methods for linear, deterministic attributes of single mode fiber and cable

    c. TIA FOTP-175-B Chromatic dispersion measurement of single mode optical fibers

    d. GR-761-CORE Generic criteria for chromatic dispersion test sets

F. Cable Plant Test Result Documentation

1. The test result information for each link must be recorded in the memory of the field tester upon completion of the test.

2. The test result records saved by the test instrument must be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of these test records. A guarantee must be made that these results are transferred to the PC unaltered, i.e., "as saved in the tester" at the end of each test. The 'csv' format (comma separated value format) does not provide adequate protection and must not be acceptable.

3. The database records of all fiber must be stored and delivered on CD-ROM; this CD-ROM must include the software tools required to view, inspect, and print any selection of test reports.

4. A paper copy of the test results must be provided that lists all the links that have been tested with the following summary information.

    a. The identification of the link in accordance with the naming convention defined in the overall system documentation.

    b. The overall Pass/Fail evaluation of the link-under-test including the Attenuation worst-case margin (margin is defined as the difference between the measured value and the test limit value).

c. The date and time the test results were saved in the memory of the tester.

5. General Information to be provided in the electronic data base containing the test result information for each link:

a. The identification of site

b. The overall Pass/Fail evaluation of the link-under-test

c. The name of the standard selected to execute the stored test results

d. The cable type and the value of the 'index of refraction' used for length calculations

e. The date and time the test results were saved in the memory of the tester

f. The brand name, model and serial number and calibration data of the tester

g. The revision of the tester software and the revision of the test standards database in the tester

6. The detailed test results data to be provided in the electronic database for each tested optical fiber must contain the following information.

a. The identification of the link/fiber in accordance with the naming convention defined in the overall system documentation.

b. The insertion loss (attenuation) measured at each wavelength, the test limit calculated for the corresponding wavelength, and the margin (difference between the measured attenuation and the test limit value).

c. The link length must be reported for each optical fiber for which the test limit was calculated per TIA-568B.

G. Fiber Optic Network End-to-End Testing:

1. End-to-end testing must be performed for all links that comprise two or more link segments that are connected via splices or patch cords.

2. In each of the following tests, inspect and clean the fiber connectors before connection to the test equipment. Test patch cords and patch panels must also be cleaned.

3. All tests must be performed in both directions for each end-to-end link.

4. End-to-End test results must be documented and submitted to VTA for approval.

H. Shielded Category 6 Patch Panel Testing:

1. Shielded Category 6 patch panels must be tested as part of the horizontal or backbone cabling system. Jacks and faceplates must be assembled complete and properly mounted. Panels must be terminated and fully dressed with proper cable management.

2. Each link or channel in the cabling system must be identified and tested individually, using at minimum an industry standard level IIIE tester, capable of testing to TIA-568-C.2 field test requirements.

3. Each panel in the cable channel or link must be tested for the shielded Category 6 parameters listed below:

a. Wire Map / Continuity:

1) Near-End Crosstalk (NEXT)

2) Power Sum Near-End Crosstalk (PSELFEXT)

b. Length:

1) Power Sum Near-End Crosstalk (PSNEXT)

2) Delay and delay skew

c. Insertion Loss:

1) Equal Level Far-End Crosstalk (ELFEXT)

2) Return Loss

4. In addition to the above test parameters, the continuity of the cable shield and drain wire must also be verified.

5. A “pass” indication must be obtained for each channel or link, using at minimum a level III tester that complies with TIA-568-C.2 field testing requirements.

6. All Shielded Category 6 Patch Panel test results must be documented and submitted to VTA for approval.

I. Category 6 Cable Testing:

1. General: Test pairs of all installed UTP wiring for full compliance with Category 6 specifications regardless of intended use. Provide documentation of test results for all conductor pairs of each cable. Perform testing using the specified Category cable tester. Test results must be approved by VTA prior to cable activation for voice, video or data applications.

2. Testing Parameters: All four pairs must meet or exceed the following measured specifications. Inspect any cable not meeting or exceeding the following for anomalies, and re-terminate or replace if necessary, to ensure compliance.

a. Line map cables to verify pin-to-pin continuity, lack of opens, shorts, and/or polarity reversals.

b. The characteristic cable impedance must be 100 ohms plus/minus 15 percent at 1 MHz to 100 MHz for 100 meters of cable.

c. Mutual capacitance of any pair at 1 kHz must not exceed 17 nF per 1000 feet.

d. Ambient noise must be less than or to 40 dB.

e. Signal to noise ratio must be greater than or equal to 7 dB.

f. Cable length must be less than or equal to 90 meters (295 feet). Total cable length including patch cables and work area cords must be less than 100 meters (328 ft).

3. All Category 6 Cable test results must be documented and submitted to VTA for approval.

J. Multiple-Conductor Copper Cable Testing: An insulation resistance test must be performed on all cables between each conductor to grounded shield and shield to ground. Cable manufacturers recommended method and values must be applied. The test must be made after cable installation, but before terminating. If the splicing or terminating is not performed immediately after cable installation, a second insulation resistance test must be made just before splicing or terminating. Each cable installation must be tested after all spliced and terminations are complete. No equipment must be connected to the cable system during tests. If any field tests fail, correct the deficiency and retest. If the test fails again, replace the entire cable segment at no additional cost to VTA.

K. Multiple-Conductor Copper Cable test results must be documented and submitted to VTA for approval.

3.09 RECOMMENDED TEST EQUIPMENT

A. Multifunction loss testers must perform the following instrument functions:

1. Loss meter
2. Power meter
3. Optical return loss (ORL) meter
4. Visual fault locator
5. Multimode and single mode light sources
6. Digital talk set
7. Fiber length tester
8. Video fiber inspection probe

B. The multifunction loss tester must be EXFO FOT-930 MaxTester or equal. The Contractor may use the testers for ORL and optical loss testing.

C. The copper and fiber cable analyzer must provide certification testing meeting EIA/TIA standards.

D. Surface inspection interferometer testing for field fiber connector termination. The surface inspection interferometer must be model DAISI Digital Automated Interferometer or equal.

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SECTION 27 15 00

COMMUNICATIONS LOW-VOLTAGE CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes the requirements for exterior (outside plant) and interior copper cabling for low-voltage serial data network communications, Public Address, SCADA monitoring and control I/O cable to be furnished and installed in this Contract

1.02 RELATED SECTIONS

A. Section 01 43 26, Initial Start-up Testing and Inspecting

B. Section 27 05 00, Common Work Results for Communications

C. Section 27 05 28, Pathways for Communications Systems

D. Section 27 11 16, Communications Cabinets, Racks, Frames and Enclosures

E. Section 27 11 19, Communications Terminal Blocks and Patch Panels

F. Section 27 13 00, Communications Network Cabling

G. Section 27 21 00, Communications Network Equipment

H. Section 27 26 00, Communications Programming and Integration Services

I. Section 27 30 00, Telephone System

J. Section 27 42 19, Public Address System

K. Section 27 42 20, Passenger Information Monitor System

L. Section 28 20 00, Video Surveillance (CCTV)

M. Section 28 31 00, Intrusion Detection System (IDS)

N. Section 28 40 00, SCADA Monitoring and Control System

O. Section 34 54 00, Automated Fare Collection System

1.03 REFERENCED STANDARDS

A. The latest versions of the following standards and references apply to the work included in this Section, in addition to those codes and standards common to all communications subsystems specified in section 27 05 00, Common Work Results for Communications. If a conflict must arise between various standards, the California state code amendments must govern, or the most strict/conservative requirement must govern.

B. American National Standards Institute (ANSI):

1. TIA-232 Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
2. TIA-455 Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components.
3. TIA-530 High Speed 25-Position Interface for Data Terminal Equipment and Data Circuit-Terminating Equipment, Including Alternative 26-Position Connector.
4. TIA-568 Commercial Building Telecommunications Cabling Standard.
5. TIA-569 Commercial Building Standard for Telecommunications Pathways and Spaces.
6. TIA-598 Optical Fiber Cable Color Coding.
7. TIA-606 Administration Standard for Telecommunications Infrastructure of Commercial Buildings.

C. American Society for Testing and Materials (ASTM):

1. B3 Standard Specification for Soft or Annealed Copper Wire.
2. B8 Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
3. B33 Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes.
4. D470 Standard Test Methods for Crosslinked Insulations and Jackets for Wire and Cable.
5. D2863 Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index).
6. D4101 Standard Specification for Propylene Plastic Injection and Extrusion Materials.
7. E662 Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials.
8. E814 Standard Test Method for Fire Tests of Through-Penetration Fire Stops.

D. Electronic Industries Association (EIA):

1. 359 Standard Colors for Color Identification and Coding.
2. 422 Electrical Characteristics of Balanced Voltage Digital Interface Circuits.
3. 492AAAA Detail Specification for 62.5-µm Core Diameter/125-µm Cladding Diameter Class 1a Multimode, Graded Index Optical Waveguide Fibers.

E. Code of Federal Regulations, Title 7--Agriculture, Subtitle B--Regulations of the Department of Agriculture, Chapter XVII--Rural Utilities Service, Department of Agriculture, Part 1755--Telecommunications Standards and Specifications for Materials, Equipment and Construction, Rural Utilities Service (RUS) Specifications:

1. TE&CM

F. Institute of Electrical and Electronic Engineers (IEEE):

383 Standard Type Test of Class IE Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations.

Insulated Cable Engineers Association (ICEA):

S-56-434 Polyolefin Insulated Communications Cables for Outdoor Use.

1. International Organization for Standardization (ISO):

G. ISO 9001 Quality Management Systems Requirements.

1. Department of Defense, Military Specifications (MIL):

H.

1. MIL-C-24643 Cable and Cords, Electrical, Low Smoke, for Shipboard Use.

I. MIL-W-81044/12 Wire, Electric, Cross-Linked Polyalkene Insulated, Tin-Coated Copper,
1. Light Weight, 600 V, 150°C.

2. National Electrical Manufacturers Association (NEMA):

J. WC 5 Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical
1. Energy.

WC 7 Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and
2. Distribution of Electrical Energy.

3. WC 57 Control Cables.

4. WC 70 Non-Shielded Power Cable 2000 V. or Less.

K. National Fire Protection Association (NFPA):

1.

2. 70 National Electrical Code, the most recent edition.

L. 262 Standard Method of Test for Fire and Smoke Characteristics of Wires and Cables.

1. Underwriters Laboratories Inc. (UL):

2. 224 Extruded Insulating Tubing.

3. 910 Test for Flame-Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables
4. Used in Spaces Transporting Environmental Air.

5. 1581 Electrical Wires, Cables, and Flexible Cords.

1.04 1666 Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in
A. Shafts.

1277 Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.

QUALITY ASSURANCE

Qualifications:

All wire and cable manufacturers must be approved by the VTA. The Contractor must provide all data required for the VTA evaluation and must make the arrangements for any required demonstrations and tests.

Qualifications must be based on the following criteria:

1. Past Performance and Experience: The cable manufacturers must demonstrate previous successful experience in supplying wire and cable specified herein. A list of such installations must be provided for each cable manufacturer to be considered.

2.

a. Quality Assurance Program: The manufacturers of cables, in accordance with the requirements of these technical specifications, are required to have in place or implement, an effective quality assurance program adhering to the requirements of ISO 9001 to ensure purchase control performance. The VTA reserves the right to audit the manufacturer's facilities for conformance
b. to the Contract. This may include, but is not limited to, first article inspections, source inspections, and on-site surveys. Such compliance must promote a thoroughly tested cable that will render long service life to the user. Prime concern must be focused on the necessary formal assurance requirements to ensure that cable failure cannot be attributed to actions or lack of actions by the manufacturer.

Technical Data: The Contractor must provide full technical data that demonstrates compliance with the requirements of these technical specifications for each specified cable type the
c. Contractor plans to supply.

d. Demonstration Tests: The Contractor must make arrangements with the prospective cable manufacturers to perform demonstration tests as required by the VTA.

e. Sample Specimens: The Contractor must, if requested, furnish to the VTA within 20 days after the Notice-to-Proceed, sample specimens in 1200 mm (4 ft.) lengths similar to that which the manufacturers proposes to furnish for each type cable specified herein. The sample specimens must remain the property of VTA.

f. The manufacturers must certify compliance with the following warranty prior to selection:

1) The manufacturers warrant that the design, material, and workmanship incorporated in each item of cable must be of the highest grade and consistent with the established, and generally accepted, standards for aerial and underground cable for transit circuits; and that each such item and every part and component thereof must comply with these technical specifications.

2) The manufacturers agree that this warranty must commence with the acceptance of each item of the cable, whether the defect be patent or latent, and must continue for a period of 8 years after initial satisfactory operation of the item or 10 years after acceptance of the item, whichever is shorter.

3) The warranty covering any length of cable that must be replaced by the manufacturers under the above conditions must be reinstated for a period of 8 years effective as of the day when said replacement is affected. If the failure is found to be of major importance and affects any other item of cable, the reinstatement of the warranty must then be extended to cover the item so affected as well, and must start as of the date of such replacement. The warranty reinstatement provided for in this subparagraph 3) must apply only to the first replacement or repair of any such item and, in the case of failure of major importance, to the first extension of the said warranty to said affected items.

4) The foregoing warranties are exclusive and in lieu of all other warranties written, oral, implied, or statutory (except as to title and freedom from lien). In no event must the manufacturer be liable by reason of breach of warranty for special or consequential damages.

B. After Selection:

1. The Contractor must monitor the manufacturers of the wire and cable to assure that the approved Quality Assurance Program is being closely adhered to and that the wire and cable is being manufactured in accordance with these technical specifications and the approved submittals.

2. Each finished wire and cable must be traceable to the test date on file for each step in its manufacturing process.

3. Inspection:

a. The VTA must have the right to make such inspection and tests as necessary to determine if the cable meets the requirements of these technical specifications. The VTA must have the right to reject cable that is defective in any respect.

b. The VTA must be given 15 days advance notice of the date the cable will be ready for final testing so that the VTA may witness the tests, if it so elects.

c. Physical tests must be made on samples selected at random at the place of production. Each test sample must be taken from the accessible end of different reels. Each reel selected and the corresponding sample must be identified. The number and lengths of samples must be as specified under the individual tests. All applicable tests for the cable materials and cable construction specified must be performed.

d. The manufacturers must provide, at the point of production, apparatus and labor for making any or all of the following tests under the supervision of the VTA to include:

1) Conductor size and physical characteristics.

2) Insulation HV and IR tests.

3) Physical Dimension Tests.

4) Special tests on materials in coverings.

5) Final HV, IR, and conductor resistance tests on shipping reels.

e. Certified electrical and physical test reports must be furnished for the finished cables no later than the time of shipment. Each test document must, in addition to the test results, indicate the date the tests were performed and the signature of the manufacturer's authorized representative.

f. The VTA reserves the right to conduct those tests to provide further satisfaction that the cable is manufactured in accordance with the requirements of these technical specifications.

1.05 DELIVERY, STORAGE, AND HANDLING

A. It must be the Contractor's responsibility to replace any cable damaged, lost or stolen at no additional cost to the Contract.

B. Packing:

1. Products must be so assembled or packed as to permit convenient handling and to protect against loss or damage during shipment.

2. Wire smaller than #4 AWG must be shipped in cartons or in coils. When shipped in coils, the wire must be securely bound with a layer of waterproof paper with each turn overlapping the other one-half its width if flat-edge paper is used, or one-third its width if folded-edge paper is used. Wires #4 AWG to #4/0 AWG, inclusive, must be shipped on nonreturnable reels protected by fiberboard covering, bound with a steel strap or wire to prevent damage in transportation.

C. Marking:

1. Purchase Order, requisition and package number, name of Consignor, and name and address of Consignee, must be plainly marked on outside of cartons, coils or reels.

2. Detail list of cartons, coils or reels must be furnished for each shipment. Where carload shipments are made, routing and car identification must be shown.

D. Handling:

1. Each shipment must be inspected by the Contractor for evidence of damage upon delivery. Any damage such as reels loose from their blockings, damaged protective wrapping or lagging, or broken flanges must be reported to the manufacturer, the carrier, and the VTA. VTA reserves the right to reject any cable damaged during the shipment, storage or handling process.

2. Cable reels must be lifted with a lifting sling and spreader attached to a shaft through the wheel hubs, or with a forklift with tines supporting both reel heads. Lift pressure must not, at any time, be placed on the cable.

3. The reels must not be lifted by the top reel flange or dropped from any height. Lift truck forks must not touch cable surfaces on the reel.

4. Reels must be rolled only on flat surfaces cleared from any debris. Direction of rolling must tighten the cable wind marked on the reel.

5. The factory-applied protective wrapping must be left in place until cable installation. After partial installation of any cable from a reel, the remaining cable must be resealed and the end tied off.

E. Storage:

1. Wires and cables must be stored at the construction site on solid surfaces which adequately support the cable reels, but which must be well drained and not allow accumulation of liquids, oils or chemicals. Reels must not be laid flat. Outdoor storage time must not exceed the manufacturer's recommendations.

2. The reels must be aligned and protected provided so as not to allow the reel flanges to damage other reels. Adequate aisles and barricades must provide accessibility but prevent construction equipment from damaging the cable reels.

3. Suitable means, such as protective barriers, must be provided to protect the cables from accidental damage during storage.

4. The Contractor, at no additional cost, must provide security against theft and vandal damage to VTA.

1.06 SUBMITTALS

A. Cable Qualification Data: Submit cable qualification data, including the following:

1. Listing of Railroads and Transit Authority Customers: Provide a list of names of five railroads and transit properties to which the manufacturer has supplied cables similar to those required by these Specifications.
2. Cable Manufacturer's Quality Assurance Program.
3. Cable Manufacturer Qualification Report.
4. Insulation Qualification Test Documentation.

B. Cable Product Data: Submit cable product data, including the following:

1. Cable cut sheets or shop drawings.
2. Certificates of Compliance confirming that wire and cable supplied meets or exceeds the requirements of these Specifications.
3. Sample Specimens: The Contractor must, if requested, furnish to the VTA within 20 days after the Notice-to-Proceed, sample specimens in 1200 mm (4 ft.) lengths similar to that which the manufacturers propose to furnish for each type cable specified herein. The sample specimens must remain the property of VTA.

C. Cable Pre-Installation Documentation: Submit as part of the Installation Plan cable installation details, including the following.

1. Pulling layout including distances and tension calculations, for each section of installation.
2. Pulling equipment and tension monitoring devices.
3. Procedures and materials for terminating the cable and preparing it for connection to the termination points.
4. Cable labeling including ID scheme, ID of each cable, and location of each tag.
5. Proposed installation procedures including:
   a. Hardware.
   b. Attachment.
   c. Routing.
   d. Conduit fill.
   e. Pull locations and equipment.
6. Proposed cable splicing procedures including:
   a. Material.
   b. Equipment.
   c. Testing.

7. Chronological plan for installing cable, including estimated time for each pull and plan for protecting cable on-reel and in slack loops during installation. Where staging of cable is required (e.g., UPRR crossing warning systems), identify details.

8. The Contractor must submit one original plus ten copies of the projected loads and voltage drop calculations and optical loss calculations.

9. The Contractor must furnish to the VTA one original plus ten copies of the cable manufacturer's instructions and procedures for potheading of each type underground cable to be furnished.

10. The manufacturer must supply one original plus ten copies of instructions for splicing for each type of cable specified. The instructions must be forwarded with the certified test results for each reel of cable. The instructions must specify the exact nature of splicing materials to be employed, and the manner they are to be spliced.

11. Conduit and Cable Schedule.

12. Cable Entrance Sealant.

D. Cable Production Test Documentation: Submit cable production test documentation, including certified test results indicating clear indication of pass/fail criteria and cable performance.

E. Cable Terminations: Submit cable and equipment data for communication cable installation and terminations.

F. Combined System Duct (CSD) and Guideway Cable Trough Acceptance Documentation: Review VTA-furnished CSD and Cable Trough, including all foundation designs and locations, and provide documentation of acceptance. Identify any problem areas and proposed workaround plan to accommodate cable installation.

G. Cable Post-Installation Documentation: Submit cable installation details, including the following:

1. Pull Tension Calculations (Post-Installation).

2. Update Conduit and Cable Schedule.

3. Conduit and Mandrel Report.

H. Cable Terminations: Submit product data and cable termination details, including the following:

1. Ring-type solder-less wire terminals.

2. Crimping tools.

3. Calibration certifications for crimping tools.

I. Test Reports. Submit test reports verifying compliance with testing requirements, per the requirements of Section 01 43 26, Initial Start-up Testing and Inspecting.

J. The VTA reserves the right to request additional submittals than those described herein at no additional cost to the Contract.

K. OCS Manual Operated Disconnects Cable Plans: Submit cable plans for all OCS monitoring cable supplied in the Contract. Indicate applicable TPSS locations, OCS poles, including conduit routing. Include updated cable and conduit schedules reflecting final routing and cable lengths.

OCS Monitoring Cutover Plan: Submit a cutover plan which comprehensively documents the planned steps, temporary equipment, and installation and testing methods to provide for continuing operation of existing operations on the Tasman East/Capitol extension while cable and equipment provided under this Contract is being installed, tested, and brought into service.

L. **MEASUREMENT AND PAYMENT**

A. Measurement: Communications Low-Voltage Conductors and Cables must be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

1.07 B. Payment: The lump sum payment for Communications Low-Voltage Conductors and Cables must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in this Section complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by VTA, and no additional compensation will be allowed therefore.

PRODUCTS

PART 2 - **GENERAL REQUIREMENTS**

2.01

The following requirements apply to all cable types.

A.

Manufacturer Qualifications Wire & Cable:

B.

1. Manufacturer Experience:

a.

Cable manufacturer must have 10 years of documented experience in supplying cable to the railway or transit industry for use in installations similar to those required by this Contract, with a minimum 305 km (1 000 000 ft.) of cable installed.

b.

Regardless of experience, provide documentation in the form of a qualification report, which identifies that the manufacturer meets the insulation qualification test requirements of these technical specifications.

2.

Insulation Qualification Tests: Provide full documentation, including certified test results, that the wire and cable manufacturer has met the qualification tests identified herein for cable insulation. No insulation failure must have occurred during these tests.

3.

2.02

Production Tests: Production tests for cable must be conducted per the manufacturer requirements for tests for non-armored cables, for armored cables, and as specified herein.

A.

B. **EXTERIOR WIRE AND CABLE**

Definition: Exterior wire and cable is defined as all communication cable installed external to communications equipment housing/room/cases. All communication wire and cable must be exterior except where interior wire or cable is specifically approved.

Application: At a minimum, unless approved otherwise, the types of cable indicated on the Contract drawings must be utilized unless smaller cable or conductor sizes can be demonstrated to meet Contract requirements. Adjust final conductor and cable sizes to account for voltage line loss, conduit fill ratio and to provide a complete operational system, and to meet spare conductor requirements.

C. Service Life: Exterior wire and cable must be of rugged construction and must have insulation and jacket materials designed for a 40 year minimum service life.

D. Voltage Rating: Unless approved otherwise, exterior wire and cable must be rated for 600 V minimum.

E. Conductors: Conductors must be solid, soft or annealed copper, and coated in accordance with ASTM B33 for tin-coated conductors. No factory splices or brazes must be made in solid conductors after final drawing. Minimum conductor size for all conductors in exterior wire and cable must be #14 AWG, unless specified or indicated otherwise.

F. Spare Requirements: Upon final adjustment of cable sizing, ensure that a minimum 10 percent spare conductors, with a minimum of two conductors in any cable have been provided.

G. Insulation:

1. Conductor insulation for all wire and cable must be vulcanized, ethylene propylene rubber (EPR) compound meeting the electrical and physical requirements for non-armored cable, and armored cable. Insulation must have moisture and heat resistance characteristics suitable for continuous operation at 90°C (194° F) in wet and dry locations, above and below ground, in trays, troughs, conduits, and duct banks.

2. The insulation must be applied concentrically and adhere tightly to the conductor surface but be free stripping and leave the conductor clean and ready for use.

H. Jacket:

1. Single conductor and multiple conductor cables must be provided with an outer jacket. Unless otherwise specified, jacket must be of extruded black low density, high molecular weight polyethylene material.

2.03 INTERIOR WIRE AND CABLE

A. Definition: Interior wire and cable is defined as all wire and cable specifically approved for installation internal to communication equipment housing/room/cases.

B. Service Life: Interior wire and cable must be of rugged construction and must have insulation and jacket materials designed for a 40-year minimum service life.

C. Voltage Rating: Interior wire and cable must be rated for 600 V minimum.

D. Conductors: Conductors for interior wire and cable must be stranded in accordance with ASTM B8 Class C, soft or annealed copper per ASTM B3, and coated in accordance with ASTM B33 for tin-coated conductors or B189 for lead-coated or lead-alloy-coated conductors. Minimum conductor size for communication housing/room/cabinet wiring must be #16 AWG, unless otherwise approved.

E. Tefzel Insulation:

1. Conductor insulation for interior wire and cable must be ethylene tetrafluoroethylene (ETFE), or cross-linked polyolefin, meeting the requirements of MIL-W-81044/12. Insulation must have moisture and heat resistance characteristics suitable for continuous operation at 90°C, in wet and dry locations.

2. The insulation must be applied concentrically and adhere tightly to the conductor surface but be free stripping and leave the conductor clean and ready for use.

Conductor insulation thickness for interior wire and cable must meet the requirements listed in Tables 1 and 2. The minimum insulation thickness at any point must not be less than 90 percent of the thickness specified.

3.

TABLE 1

Solid Conductor Wire Rated at 600 V

Size (AWG)	Insulation Thickness [mm (in.)] Nominal	Test Voltage V (ac)	Test Voltage V (dc)
#30	0.127 (0.005)	2000	6000
#26	0.127 (0.005)	2000	6000
#24	0.254 (0.010)	2000	6000
#22	0.254 (0.010)	2000	6000
#20	0.254 (0.010)	2000	6000

TABLE 2

Stranded Conductor Wire Rated at 600 V

Size (AWG)	Strands	Insulation Thickness [mm (in.)] Nominal	Test Voltage V (ac)	Test Voltage V (dc)
#22	19 x 34	0.381 (0.015)	3000	9000
#20	19 x 32	0.381 (0.015)	3000	9000
#18	19 x 30	0.381 (0.015)	3000	9000
#16	19 x 29	0.381 (0.015)	3000	9000
#14	19 x 27	0.381 (0.015)	3000	9000
#12	37 x 28	0.508 (0.020)	3000	9000
#10	37 x 26	0.508 (0.020)	3000	9000
#8	133 x 29	0.508 (0.020)	3000	9000
#6	133 x 27	0.508 (0.020)	3000	9000
#4 *	133	0.610 (0.024)	3000	9000
#2	665	0.660 (0.026)	3000	9000
#1	836	0.711 (0.028)	3000	9000
#1/0	1064	0.762 (0.030)	3000	9000
#2/0	1323	0.991 (0.039)	3000	9000
#3/0	1672	1.397 (0.055)	3000	9000
#4/0	2107	1.524 (0.060)	3000	9000

F.

1.

Physical and Electrical Properties: ETFE wire and cable must meet the following requirements:

Tensile Strength: 34.5 MPa (5000 psi), minimum.

2. Elongation: 150 percent, minimum.
3. Air Oven Aging (168 hrs at 200°C (392°F), 2200 V rms, 60 Hz):
    a. Tensile strength: 80 percent of un-aged value, minimum.
    b. Shrinkage at 200°C +/- 2°C (392°F +/- 4°F): 3.175 mm (0.125 in.), maximum.
    c. Elongation: 80 percent of aged value, minimum.
    d. Elongation: 60 percent of un-aged value, minimum.
    e. Oil Immersion, 7 days at 150°C (302°F): tensile strength of un-aged value: 90.
    f. Wrap Test, #20 AWG wire, 2 hours at 200°C (392°F): No cracks.
4. Heat Distortion at 150°C (302°F): 80 percent of un-aged value, minimum.
5. Heat Shock for 7 hours at 210°C (410°F): No cracks.
6. Cold Bend at - 65°C (- 85°F): No cracks.
7. Insulation resistance constant at 16°C (60°F): 50 000, minimum.
8. Dielectric constant at 25°C (77°F): 2.75, minimum.
9. Maximum percent increase in dielectric constant in 75°C (167°F) water:
    a. 1 to 14 days: 1.0
    b. 7 to 14 days: 1.0
    c. Stability factor after 14 days: 1.0, maximum.
10. Ozone resistance, 3 hours at 0.025 percent concentration: No cracks.
11. Mechanical water absorption, 7 days: 35.
12. Oxygen index: 28.
13. Dynamic cut-through: 90.

G. Temperature Rating: Wire and cable insulated with ETFE must be rated at 150°C (302°F) maximum normal conductor rating.

H. Fit: Insulation must be applied directly to the surface of the conductor and must adhere tightly to the surface, but must be free stripping and leave the conductor clean.

I. Identification: Each stranded wire must be marked at maximum intervals of 900 mm (3 ft.), with manufacturer's name, size of conductor, and type of insulation.

J. Cable Jacket Thickness: The average thickness of the jacket on cables jacketed with ETFE must be not less than the values given in Table 3. The minimum thickness must not be less than 80 percent of the values indicated.

TABLE 3

Cable Core Diameter mm(in.)	Jacket Thickness mm(in.)
0 to 6.35 (0.250)	0.381 (0.015)
6.38 (0.251) to 10.8 (0.425)	0.762 (0.030)
10.81 (0.426) to 17.78 (0.700)	1.02 (0.040)
17.79 (0.701) and larger	1.27 (0.050)

K. Multiconductor Cable: Multiconductor cable must be made by assembling twisted pairs of insulated conductors into a tight cylindrical form using non-hygroscopic, flame-resistant fillers and tape, and the jacket used must likewise fit tightly to form a firm assembly.

1. Fillers used to fill interstices to make the cable assembly round must be able to shape themselves to fill the interstices. Fillers must be compatible with the other materials in the cable.

2. Each layer of two or more wires must have a helically applied fabric or mylar tape with a minimum of 25 percent overlap to serve as a binder. Tape thickness must be not less than 0.127 mm (0.005 in.) unless otherwise approved. The tape must be compatible with other materials in the cable.

3. All multiconductor cables (twisted pair) must be cabled together with a nominal lay of 38 mm +/- 13 mm (1.5 in. +/- 0.5 in.). High twist multiconductor cables must be cabled together with a length of lay 25 mm, + 6 mm - 3 mm (1 in., + 0.25 in. - 0.125 in.).

4. Provide tinned copper conductors, Tefzel insulated, cabled over all aluminum shield and drain wire Tefzel jacket.

L. Identification: Individual conductors of multiconductor cables must be identified by means of solid colors, colored coatings with or without stripes.

M. Testing:

1. Physical and electrical properties of ETFE must be tested in accordance with NEMA WC 5, as applicable, unless otherwise specified or approved.

2. Each length of insulated conductor prior to application of any jacket and prior to cabling or twisting must be wound on reels and immersed in room temperature water before conducting voltage and insulation resistance tests. DC voltage tests must be performed after a minimum of 16 hours immersion. AC voltage tests must be performed after a minimum of 24 hours immersion. The AC test voltage must be applied for 5 minutes and the DC test voltage must be applied for 10 minutes. The voltage must be applied between conductor and water (ground).

N. Voltage and Insulation Resistance Preliminary Tests: Immediately after the AC test and while the insulated conductor is still submerged, an insulation resistance test must be performed on each length of insulated conductor. The insulation resistance constant for 305 m (1000 ft.) must not be less than 500 kΩ when corrected to 16°C (60°F), minimum.

O. Conductor Resistance Test. Each length of cable while on the shipping reel must be subject to a conductor resistance test. Resistance must not exceed those values indicated in Table 4.

TABLE 4

Resistance at 20°C (68°F)

Conductor Size, AWG	Ohms/305 meters (1000 ft.) (maximum)
22	16.2
20	9.88
18	6.23
16	4.81
14	3.06
12	2.02
10	1.26
8	0.701
6	0.445
4	0.280
2	0.183
1	0.149
0	0.116
00	0.091

P. Voltage Final Test. Each reel of finished multiconductor cable must be subject to a 60 Hz test voltage equal to two times the test voltage specified in Tables 1 and 2, as applicable. The voltage must be applied for one minute and must be applied between adjacent insulated conductors and between adjacent layers of insulated conductors in the cable using mid-tap grounded transformer. The metallic shield, if present, must be connected to ground. All finished cables must be immersed in water at room temperature for 48 hours. While still immersed, all conductors must be tested for breakdown at 2.5 kV (RMS) for five minutes.

Q. Dynamic Cut-Through:

1. Perform the dynamic cut-through test at room temperature, using a tensile testing machine equipped with a recorder that must be suitable for recording the force necessary to force a tungsten carbide cutting tool through the insulation of a finished wire specimen. This cutting tool must have a cutting edge of 0.127 mm (0.005 in.) radius of curvature on a 90-degree wedge. Equip the testing machine with a 12 V detection circuit designed to stop the testing machine when the cutting edge cuts through the wire insulation and contacts the conductor.

2. Remove 25 mm (1 in.) of insulation from one end of a 450 mm (18 in.) finished-wire specimen. Place the specimen on a hard, flat surface with the cutting edge perpendicular to the axis of the wire specimen. Force the cutting edge through the insulation at a constant rate of 5 mm/min (0.2 in./min) until contact with the conductor occurs. Record the force measured at the time of contact with the conductor. Perform four tests on each specimen, with the specimen being moved forward 25 mm (1 in.) minimum and rotated clockwise 90 degrees between each test. The cut-through resistance must be the average of the four test result values, 400 N (90 lb.) minimum at 23°C (73.4°F) with size #20 AWG stranded wire.

R. Flame Test: Stranded single conductor and multiconductor cables must pass the vertical tray flame test as detailed in IEEE 383 using a ribbon gas burner as the flame source. Circuit intensity must be monitored for short circuits and ground conditions by an electrical test circuit utilizing a three-wire, 120 V to 240 V service. Conductors must sustain circuit integrity for a duration of five minutes minimum.

S. Test Samples: Physical and electrical characteristic tests must be performed on at least one sample from each type and size of wire and cable unless otherwise specified herein. AC and DC voltage, insulation resistance, and conductor resistance test must be performed on all wire and cable. Flame and smoke tests must be performed on representative samples, as approved.

T. Test Reports: Reports must contain sufficient information and test data to demonstrate that the wire and cable supplied meets or exceeds these Specifications. As a minimum, certified test reports must contain the following:

1. Date and location of test.
2. Description of test and conditions.
3. Lot identification number.
4. Quantitative test results.
5. Summary of test results.

2.04 PUBLIC ADDRESS, AND I/O CABLE

A. General:

1. The life expectancy of the cable must be 40 years in a railroad and transit environment.
2. The cable must be constructed for continuous operation at 90°C (194°F), in a wet or dry environment.
3. Conductor to conductor and conductor to ground resistance must not be less than one meg-ohm.
4. The cable must be constructed for continuous operation at -40°C (-40°F) without cracking or becoming brittle.
5. Wire conductors must be composed of soft or annealed copper, meeting insulating, sensitivity and elongation requirements of ASTM B3, latest edition. Unless otherwise indicated in the Plans or approved by VTA, the wire size must be #22 AWG for the 12-pair cable.
6. The insulation must be colored virgin propylene copolymer meeting the requirements of ASTM D4101, or equivalent, for propylene plastic. High molecular weight polyethylene is also acceptable.
7. Insulated conductors must be in twisted pairs. Each pair must be individually colored. The average length of pair twist must not exceed 150 mm (6 in.). To minimize noise and crosstalk, each pair of a 12-pair cable must have a different average length of twist from any other pair in the cable.
8. All outside I/O communications cables (those run in conduits, duct banks or troughs must be foam/skin insulated conductors that meet RUS Specification 7 CFR 1755.890 and must be rodent protected.
9. All main and riser paired cables must be shielded.

10. No cable must contain less than 12 pairs unless otherwise indicated in the Plans and must have at least 50 percent spare pairs. In addition to the requirements listed herein, all cables must meet the requirements of NFPA 70 and 130 latest editions and must be manufactured to telephone industry standards.

B. PA Cable:

1. Contractor must provide loudspeaker wiring in accordance with Section 27 42 19, Public Address System and with Contract Drawings.

2. Loudspeaker cables must be shielded twisted pairs, #14 AWG stranded, minimum. Local distribution cables for the PA system must be placed in separate conduit or raceways from low-level voice and data circuits.

3. Loudspeaker wiring must be provided for connection of speakers at all stations.

4. Unless otherwise indicated in the Plans or approved by VTA, ambient sensing microphone cable must be shielded twisted pairs, #18 AWG.

C. Data Cable:

1. ANSI TIA-232 Applications. Serial data cables used for RS-232 applications must meet the following characteristics:

   a. Jacket: NEC CL2P, Low Smoke.
   b. Wires: Uniquely Color Coded.
   c. Cable Type: Twisted pair.
   d. Conductor gauge: #24 AWG (7 X #32 AWG) stranded, minimum.
   e. Shield: 1 overall foil shield, with a braided shield minimum.
   f. Capacitance: ≤40 pF/m (≤12 pF/ft).
   g. Resistance: ≤100 Ω/km (≤30 Ω/1000 ft).
   h. Conductors: 6 to 12 half- pairs.

2. EIA-422 and ANSI-530 Data Communications Cable. Serial data cables used for RS-422 or RS-530 balanced electrical transmission of data must meet the following characteristics:

   a. Jacket: NEC CL2P, Low Smoke.
   b. Wires: Uniquely Color Coded.
   c. Cable Type: Twisted pair.
   d. Conductor gauge: #24 AWG (7 x #32 AWG) stranded, minimum.
   e. Shield: Individually foil shielded pairs each with a drain wire. One overall foil shield, with a braided shield minimum.
   f. Capacitance: ≤43 pF/m (≤13 pF/ft).
   g. Resistance: ≤30 ohms/1000 ft.

Characteristic Impedance: 100 ohms.

Conductors: 2 to 12 pairs.

Outdoor I/O Data Cable: Contractor must furnish, install and terminate I/O data cabling as indicated in the Contract Drawings.

h.

i. The 25-pair #19 AWG, 12-pair #14 AWG and 12-pair #19 AWG, filled, cable must conform to RUS Specification 7 CFR 1755.890 except as noted herein.

D.

The conductors must be solid annealed bare copper conforming to the latest requirements of ASTM B3. Unless otherwise indicated in the Plans or approved by VTA, the conductors must be #19 AWG.

1.

Conductors must be individually insulated with a colored, solid insulating grade, high density-polyethylene or polyolefin of ICEA S-56-434.

2.

a. The insulating material color must be coded per U.S. telephone industry standards with color concentrates chosen for permanency and electrical balance of individual circuits. The colors of

b. insulated conductors must be supplied in accordance with ICEA S-56-434, Section II-7 and must comply with the requirements of EIA TIA-359.

The insulated conductors must be twisted into pairs. The length of pair twists must be designed to meet ICEA S-56-434.

c.

The average twist length of any pair in the finished cable must not exceed 150 mm (6 in.).

d.

e. The insulated pairs must be twisted into specified color combinations to provide pair identification as well as low susceptibility to noise pick-up and with varying lay lengths to minimize cross-talk.

f.

The insulated pairs must be assembled into a cable core. Cable cores of 25 or less pairs must be assembled concentrically. Cable cores of more than 25 pairs must be formed of 25 pair units.

3. Each 25 pair unit must be wrapped with a color-coded non-hygroscopic binder.

The filling compound, a petroleum jelly base multi-component, must be applied to the cable core in such a way as to provide as near to 100 percent fill of the available air space within the core as is commercially practicable. The filling compound must be applied in a manner to fill all voids and

4. conductor interstices under the core to restrict the migration of moisture. The filling compound must be compatible with the insulation and other cable components.

5.

The filled core must be completely covered with a layer of non-hygroscopic, non-wicking polymeric tape applied with overlap over the cable core to ensure high dielectric strength from cable core to shield.

6.

A 0.2 mm (0.008 in.) thick corrugated aluminum tape must be applied over the core. The tape must be coated with a 0.05 mm (0.002 in.) thick, copolymer compound and must be applied longitudinally with overlap.

7.

The outer jacket must be of virgin, black high molecular weight polyethylene copolymer except low-smoke jacketed cables that must be as specified below. The overall jacket must be sequentially marked at 600 mm (2-ft.) intervals with cable type, year of manufacture, footage, pair count, conductor size and manufacturer. The jacket must be free from holes, splits, blisters or other imperfections and must be smooth and concentric.

The following factory tests must be performed:

a. Conductor insulation must be tested per RUS Specification 7 CFR 1755.97 Bulletin 345-63, "RUS Standard for Acceptance Tests and Measurements of Telephone Plant," for the following:

	Test	Minimum Criteria
1)	Minimum Tensile Strength:	16.5 MPa (2400 lb./sq. in.).
2)	Ultimate Elongation:	300 percent minimum.
3)	Maximum Shrinkback:	9 mm (3/8 in.).

b. The jacket material must be tested per RUS Specification 7 CFR 1755.97 Bulletin 345-63, "RUS Standard for Acceptance Tests and Measurements of Telephone Plant," for the following:

	Test	Minimum Criteria
1)	Minimum Tensile Strength:	12 MPa (1700 lb./sq. in.).
2)	Ultimate Elongation:	400 percent minimum.
3)	Environmental Stress Cracking:	20 percent maximum.
4)	Maximum Shrinkback:	5 percent.
5)	Impact Failure:	20 percent maximum.

c. The finished 25 and 12-pair cable must be tested per RUS Specification 7 CFR 1755.97 Bulletin 345-63, "RUS Standard for Acceptance Tests and Measurements of Telephone Plant," for the following:

	Test	Minimum Criteria
1)	Mutual Capacitance: [0.083 +/- 0.004)µF/mi.].	(0.052 +/- 0.0025) µF/km
2)	Mutual Capacitance:	3 percent rms max. deviation
3)	Mutual Conductance (1000 Hz.):	2.05 µΩ/km (3.3 µΩ/mi.).
4)	Pair-to-Pair Capacitance Unbalance:	82 pF/km (25 pF/1000 ft.).
5)	Pair-to-Ground Unbalance (maximum):	2.6 nF/km (800 pF/1000 ft.) max.
6)	Pair-to-Ground Unbalance (average):	575 pF/km (175pF/1000 ft.) max.
7)	Far End Crosstalk (150 kHz):	210 db/ km (63db/1000ft.) (RMS).
8)	Near End Crosstalk (772 kHz):	56 M-S dB.
9)	Insulation Resistance:	620 MΩ/km (1 GΩ/mi.).
10)	Maximum Conductor Resistance: [at 20°C (69°F)]	28.5 Ω/km (45.9 Ω/mi.).
11)	Maximum Average Attenuation: [1 kHz at 20°C (69°F))	0.80 dB/km (1.29 dB/mi.).

12) High Voltage Test (3 seconds): 3.6 kV (dc) (Between Conductors).

13) High Voltage Test (3 seconds): 7 kV (dc) (Between Conductor and Shield).

14) Cable Bend Test: No Shield Cracks.

Low Smoke Jacket: I/O cable entering from an outside environment exceeding 15 m (50 ft.) in length inside a facility must be low smoke. Low smoke jacket material for outside telephone or I/O data cables must be flame retardant cross-linked polyolefin, as approved by the VTA. The jacket thickness must be 1.5 mm (60 mils) minimum.

8. Jacket material must meet or exceed the following specifications:

	Test	Minimum Criteria
a. 1)	Tensile Strength (ASTM D470):	7.6 MPa (1100 psi).
2)	Elongation (ASTM D470):	200 percent.
3)	Tear Strength (ASTM D470):	3 kN/m (17 lb/in.).
4)	Oxygen Index (ASTM D2863):	27.
5)	Smoke Density (ASTM E662):	
•	Flaming Mode Ds 4 min.:	50.
•	Flaming Mode Dm 20 min.:	175.
•	Nonflaming Mode Ds 4 min.:	65.
•	Nonflaming Mode Ds 20 min.:	300.
6)	Smoke Index (MIL-C-24643):	25.
7)	Halogen Content (MIL-C-24643):	0.2 percent.
8)	Toxicity Index (MIL-C-24643):	8.0.
2.05 9)	Acid Gas Equiv. (MIL-C-24643):	2.0 percent.
A. 10)	Ozone Resistance (ASTM D470):	(150 ppm at 25°C (°F)) Pass.

TERMINALS

General: Supply terminals for termination of wires and cables as per the manufacturer recommendations and approved by VTA and as required in various sections of these technical specifications. Terminals must be provided in the communication room/cabinets, and at all communication system interface devices unless specified otherwise.

2.06 TRACTION POWER SYSTEM, OCS MANUAL OPERATED DISCONNECT SWITCH CABLE

A. Cable:

1. Provide control cable in the CSD between traction power substations, and between traction power substations and OCS poles with disconnect switches for transfer, and for monitoring the status of the disconnect switches and OCS voltage.

2. The OCS disconnect switch control cable must consist of stranded 12-#14 AWG copper conductors arranged in 6 twisted pairs, with an overall shield and jacket. The control cable must be rated for 600 V operation and comply with UL 1277. The insulation must be ethylene-propylene rubber (EPS) compound complying with NEMA WC 57 and NEMA WC 70. The overall shield must be made of 5-mils thick flat copper tape, wound continuously with 12-13 percent overlap. The overall jacket must be chloro-sulphonated polyethylene (CSPE) or Hypalon, meeting or exceeding the requirements of UL 1581.

3. The cable and conductor schedules in the Contract Drawings provide an estimate on cable lengths and proposed conduit routing. Obtain the latest design and installation drawings of the CSD from the VTA in order to determine cable pulling information, such as routing geometry and precise locations of pullboxes and manholes, conduit stub-ups, OCS pole locations and TPSS locations. The Contractor must be responsible for determining the cable reel and cut lengths, and must confirm these by field inspection of the CSD prior to ordering the cable.

4. Wiring and material must conform to the NEC, ANSI C2, and VTA design criteria.

B. Cable Plans: Provide cable plans for all OCS monitoring cable supplied in the Contract. Indicate applicable TPSS and OCS pole locations, including conduit routing.

C. SCADA Plans: Provide SCADA plans that show the interfaces to the field devices, including pole mounted disconnect switches and include as part of the applicable design review plans.

D. Splices: Cable pull lengths must be maximized so as to minimize splices. Splices, if approved by the VTA, must be allowed in manholes only. Where installed, provide splice supports on both sides of the splice.

E. Tagging: The Contractor must submit for VTA approval the identification tag data and samples for the equipment specified below:

1. Provide individual conductor markers for all cable conductors in accordance with the circuit number indicated on the conductor and cable schedule. Label unused conductors as spare.

2. Provide a cable tag for each end of each cable. A unique identifier must be assigned to, and marked on each cable to serve as a link to the cable record. Both ends of each cable and each cable wire and all single wires that terminate in equipment cabinets, equipment terminal blocks, punch down blocks and computers must be permanently identified with a tag. Tags must not obscure connection links used between terminal binding posts. Tags must be installed so that they may be read with a minimum of disturbance to the tags.

3. Verify final nomenclature on each individual conductor with the VTA prior to manufacture.

F. Staging and Cutover:

1. Plan and schedule design, field staffing, installation, interfacing, instrumentation, testing, acceptance, and documentation activities to anticipate and meet the special conditions imposed by existing operations on the Tasman East/Capitol extension.

Prepare a cutover plan which comprehensively documents the planned steps, temporary equipment, and installation and testing methods to provide for continuing operation of existing operations while cable and equipment provided under this Contract is being installed, tested, and brought into service. Address, at a minimum, installation, test, and cutover of cable in the existing CSDs on the Tasman East/Capitol line, and at existing TPSS #28.

PART 3 - EXECUTION

3.01 APPLICATION

A. General: At a minimum, unless specified or approved otherwise, provide cable as indicated in the Contract Drawings. Adjust final conductor and cable sizes, and routing, to account for voltage line loss to provide a complete operational system, and to meet spare conductor requirements.

3.02 INSTALLATION

A. Installation Plan:

1. Develop a written cable installation procedure and check-off list for approval prior to cable installation. Base the procedure on the review of the conduit plans and field site survey, and include a cable plan and installation information for each cable pull.

2. The installation plan must include proper procedures for feeding cable into conduit, to maintain proper bend radii, and to minimize friction.

3. Document, and submit as part of the cable installation records, the Conduit and Cable Schedule, provided in the Contract Drawings indicating in what conduit each cable is to pulled in the CSD. Indicate where multiple cables installed in one conduit transition to other multiple use or individual local conduit. Update the table after installation is complete.

4. Identify staging work associated with installation and removal of existing cable. Existing equipment must remain operational at all times, with the exception of approved shut-down periods.

5. Install cable per the approved installation and cable plans.

B. General:

1. The installation of wire and cable must conform to applicable sections of NFPA 70 and the requirements as specified herein.

2. Installation of communications cable must conform with RUS TE&CM Parts 641 and 644, and ANSI TIA-568 and ANSI TIA-569 and to applicable sections of NFPA 70 and the requirements as specified herein.

3. Exposed wire and cable will not be permitted along the wayside, unless pre-approved.

4. Contractor must be responsible for verifying the required cable length for each cable run prior to installation. Civil stationing appearing on referenced drawings may be used for defining locations and estimating cable lengths. However, no existing drawings must be used to determine final lengths and cuts. Actual lengths must be determined by making on-site inspections and measurements.

Wires and cable must be continuous without splices between junction boxes, terminals, pull boxes, manholes and hand holes.

Cable must not be bent to a radius less than the greater of 12 times the diameter of the cable or the manufacturers' recommended minimum bending radius, during installation or as finally installed.

5. Install wire and cables in conduits, cableways, and troughs after all conduits, cableways, and troughs are in place, all related work is completed, and the area cleared for a safe working condition. Cables must be laid into cableways and troughs, rather than pulled wherever possible.

6.

Cable must be laid with a minimum amount of crossover, must be secured at least every 900 mm (3
7. ft.), and must not be pulled or formed tightly around bends. Conduits for cables entering or leaving trays must be rigidly attached and supported at their ends by suitable brackets and conduit straps.

8. Cable must be protected immediately after installation and prior to terminating or splicing. All cables must be tagged and labeled immediately after installation. Cables must be tagged at their termination points. In addition, all cables must be tagged within Signal Rooms, Signals Cases, Communications
9. Rooms/Cabinets, manholes, handholes, housings, etc. and on each side of any barrier the cable passes through. Cables must also be tagged at aerial exits from conduit risers. Re-seal cable ends when a length is cut from a reel.

Install grommets or use other methods to protect incoming cables to houses/rooms/cases, and other
10. equipment, from abrasion. Where cables are routed vertically, provide proper support as necessary to relieve strain. In no case must the weight of cables be allowed to pull against cable terminations.

11. All exposed wires and cables entering or leaving signal/communications equipment housing/room/cases, junction boxes, and cable transition points must be protected from abrasion. Chase nipples and/or split ring plastic grommets must be provided in drilled or punched openings in equipment housing/room/cases and junction boxes.

12.

All cable entrance openings must be sealed with either a compression type fitting or pliable sealing compound after the cable is in place. Sealing compound must be used to seal the area around cable where the cable emerges from the end of a conduit or pipe. All spare conduits must be sealed or plugged in an approved manner. Cable openings within the substation and signal housing floors
13. and/or walls must be sealed with an approved fire sealant per ASTM E814.

14. Where cables leave conduits, the ends of the conduit must be fitted with end bells to prevent damage to the cable.

Provide sufficient slack in installation of wire and cable for relief of stress due to vibration and to
15. allow for 3 re-terminations of each conductor without re-servicing or re-potheading the wire or cable. Contractor must provide service loops sufficient for the maintenance and free movement of attached electrical equipment.

Where multi-conductor cables are to be terminated in an enclosure, the outer jacket and shield (where applicable) must be carefully removed to a point close to the cable entrance. At the end of the cable sheath or covering, apply two layers of an approved electrical plastic tape. Conductors must then be neatly arranged, bundled, and tied approximately every 75 mm (3 in.). These bundles must be routed vertically to a point higher than the top terminal post and then turned and terminated from the top terminal down in reverse wire number order (highest number at the top). Observe all wire bend radius restrictions. Cable connections and splices must be made in strict accordance with the manufacturer's instructions.

Grounding must meet the requirements and practices of applicable local, state, and federal codes for the specific cabling system they protect. Additionally, all telecommunications grounding/bonding must conform to TIA/EIA-607 requirements.

All copper power and signal wiring leaving/entering communication rooms/cabinets, equipment housings must be equipped with surge suppressors. Surge suppressors must be designed to prevent damage to the equipment from power surges and transient voltages caused by lightning and other environmental factors.

The Contractor must install, terminate, and test all cables employing qualified personnel. The foreman for any cable-pulling task must have a minimum of two years of experience in the pulling of cables through conduit/duct systems. Technicians performing cable installation, termination, and testing must have been trained and certified in the tasks assigned to them. This training must have been in an industry recognized training course and the technicians must be certified to have successfully completed the entire course of study.

Cables with bronze tape shield must have the shield grounded on one end of each cable run. Submit a shield grounding plan for approval. Shield grounding materials must be provided per the approved grounding plan.

Open wiring on equipment racks must be neatly arranged, bundled, and tied approximately every 75 mm (3 in.) with nylon straps. All straps must be of the same color.

Remaining cable tails and reels over 60 m (200 ft.) may must be delivered to VTA at the discretion of the VTA. All cable tails and reels not delivered to VTA must be disposed of by the Contractor.

Contractor must arrange the cables to allow free access to all existing cables for maintenance. Cables must be placed in conduits identified to the Contractor by the reference drawings.

Cables must be installed with freedom of horizontal movement to accommodate expansion and contraction of the cables in the conduits.

Cables must not be pulled into a conduit that already contains cables or conductors. If it becomes necessary to remove a cable from a conduit, all cables in that conduit must be removed. Cable removed from conduit must not be reinstalled or used elsewhere.

The Contractor must provide appropriate special protection for cables in areas where the cables are unavoidably exposed to hazardous conditions such as vibration or sharp corners on equipment. Cables damaged due to Contractor's neglect while installing cables must be replaced by the Contractor at no additional cost to the Contract.

Cable installation in conduit must not exceed 40 percent fill per conduit, unless otherwise allowed by the VTA.

Cables installed in manholes must be properly constrained and fastened to the walls of the manhole in accordance with the approved installation drawings.

All wires and cables must be identified whenever they enter or leave a junction box, manhole, housing, or enclosure, and at all terminations. Wire designations must consistently conform to an overall scheme prepared by the Contractor and approved by the VTA to indicate location, circuit, device, wire number, terminal branch, position, etc. Letters and numbers must be used.

Notification: Notify the VTA 48 hours prior to any cable installation activities.

C. Ductbank:

1. The CSD will be installed as part of separate contracts to accommodate signal, power, and communication cable installation requirements. Review and verify that all conduits are adequate for the Signal and Communications Systems. Provide documentation of CSD acceptance, including acceptance of CSD manholes, pullboxes, and vaults.

2. Perform extension of conduits and minor modifications or changes to the duct system to support signal and communications requirements, at no cost to VTA. Coordinate signal and communications conduit utilization to minimize cable crossovers in pullboxes and to provide a professional finished product.

3. Provide additional conduit as required to access signal equipment enclosures.

4. Cable installed in conduit, regardless of length, must not exceed the maximum fill recommendations of the manufacturer, unless otherwise approved.

5. Provide any installation hardware necessary to route, support, terminate, or protect cable.

6. Ensure that conduits are dry before installation of cable and use a pulling compound or lubricant approved by the manufacturer, which is compatible with the cable. Utilize the lubricant in the quantity recommended by the lubricant supplier and must be applied in a manner that ensures that the cable is lubricated throughout the entire length being installed. The lubricant must be non-hygroscopic and vermin-proof.

7. All wires and cables to be installed in a conduit must be installed at the same time. If it becomes necessary to remove a cable from a conduit, all cables in that conduit must be removed. Cable removed from a conduit must not be reinstalled or used elsewhere

8. Cable made expressly for the purpose of direct burial must not be installed in conduit.

9. Inspect manholes and pullboxes for structural correctness and cleanliness prior to accepting an area as suitable for installation to proceed.

10. Remove covers as required for installing cable. Covers must be placed along right of way so that movement of trains or construction vehicles is not impeded. Care should be taken to prevent damage to the covers. Contractor must be responsible for any damage to cover during cable installation. If any damage is evident prior to cable installation, it should be brought to the attention of the VTA.

11. Install manhole (and pullbox, where applicable) cable racks prior to installing cable. Refer to Section 27 05 28, "Pathways for Communications Systems," for additional requirements.

12. Dewater and remove dirt and trash from manholes and pullboxes prior to and during installation of cable.

13. When conduit is being extended by the Contractor to complete the installation, mandrel each conduit and document results on the Conduit and Mandrel Report.

14. Cables installed in manholes must not interfere with the future use of or access to unused conduit.

D. Cable Pulling:

1. Calculations must be made to estimate pulling tensions for cable pulls, which require the use of pulling apparatus. These tensions must be calculated in both directions to determine which will result in less stress on the cable. The direction requiring lower tension must be used where possible. Indicate how each installation will be completed within the limitations and recommendations of the manufacturer and these technical specifications. All installation calculations must be submitted to the VTA prior to the start of cable installation. Tension calculations need not be provided for short sections of cable, which will be installed by hand pulling.

2. Apparatus to be used in pulling-in cable must be in good working order and must be demonstrated to the VTA for approval. Pulling apparatus must be provided with a smooth variable speed control. A dynamometer must be used for all cable installations that are not installed by hand. The dynamometer used for cable pulling must bear a record of calibration against certified standards indicating calibration within the last 180 days.

3. Two-way communication between the pulling and feed end of each pull must be established before and maintained during the installation.

4. Reels must be stripped of all nails in outside edges of reel heads before pulling of cable, and must be conveniently located for feeding cable into the conduit without excessive bending or possible injury to cable by abrasion on sides of pull boxes where pull boxes are required. Reels must be jacked to clear ground level by at least 150 mm (6 in.) before pulling cable.

5. Cable reels must be carefully handled to avoid injury to persons or cables. Movement of reels on loading skids or sloping grades must be controlled by use of a snub line or wedge. Reels must always be blocked after positioning.

6. Cable must be pulled into conduits with the use of a pulling eye approved by the VTA. Pulling ropes must be attached to the pulling eye with ball-bearing swivels to prevent twisting of cable during pulling.

7. Cable must be pulled into conduits under moderate tension. Manufacturer's recommended maximum pulling tension must not be exceeded at any time. Before pulling any cable into conduits, the Contractor must first consult with the VTA as to methods and locations of cable pulling.

8. Personnel must be stationed between the reel and the conduit entrance during pulling operations to inspect control and direct the passage of cable. The conduit mouth must be equipped with conduit shields to prevent chafing of the cable. Use UL-listed lubricant and provide suitable installation equipment to prevent cutting and abrasion of wire during the pulling of feeders.

9. Avoid using any lubricant that may be injurious to the materials of the wires and cables to be installed. Provide installation procedure as recommended by the cable manufacturer, and approved by VTA.

10. Cable must not be allowed to chafe on the ground, in manholes or handhole edges, or any sharp surfaces during pulling. Flexible pulling tubes must be provided to guide and protect the cable, where necessary.

11. Pulling must be done at a constant velocity, not less than 5 m/min (15 ft./min) nor more than 15 m/min (50 ft./min), unless otherwise recommended by the cable manufacturer. The pull must not be stopped once started unless absolutely necessary.

12. Measure, record, and submit the dynamometer reading and the actual pulling tension for each pull along with any conversion calculations and a copy of the certificate of calibration for each instrument. These cable installation records must be filled out in the field and signed and dated by the installation/test engineer. Contractor must submit the original forms to the VTA.

13. After pulling, the tension end of the cable damaged in the pulling process must be cut off.

E. Communications Wire Terminations

1. For stranded copper wire, compression-type, insulated terminals in accordance with the wire and cable manufacturers' recommendations must be used. The terminals must be installed only with tools and techniques recommended by the terminal manufacturer. Solid wire must be terminated by wire eyes.

2. Wires and cables must be terminated at terminal blocks. Compression-type insulated terminal connections to terminal blocks must use a single washer on top of the terminal. Wire eyes require two washers for one eye, three washers for two eyes. Connections must be completed with double nuts torqued to the rated value of the nut.

3. Terminations for LAN unshielded twisted pair cabling must be performed with the proper tools for terminating Category 6 RJ-45 connectors in accordance with TIA/EIA 568.

F. Tagging: Tag wire and cable as approved by VTA.

3.03 TRACTION POWER SYSTEM / OCS DISCONNECT SWITCH CABLE

A. Existing Operations: Perform work in a manner which provides for continuing operation of existing operations on the Tasman East/Capitol corridor while equipment provided under this Contract is being installed, tested, and brought into service.

B. Termination: Terminate all cable (e.g., substation interface cabinets, OCS pole interface boxes). Coordinate specifics with the VTA.

C. Installation:

1. Install cable in accordance with the conductor and cable schedules in the Contract Drawings. Obtain final CSD plans from the VTA and revise accordingly.

2. Separate traction power control and monitoring cable from Communications cable to the greatest extent possible. Where possible, install on separate sides of the CSD manhole. In existing territory, secure cable to existing cable with nylon ties.

3. Conduit with an identification (ID) number of 18 must be maintained as spare to the extent possible.

4. Installation must conform to the NEC, ANSI C2, and VTA design criteria.

D. Schedule As-Builts: Update the attached conduit and cable schedules to reflect final as-installed conditions. Schedules must correspond with final Contractor-provided cable plans. Electronic copies of the schedules can be obtained through the VTA.

E. Splices: Splices must be installed with care in order to ensure a watertight fit. Notify the VTA of each splice completion for visual inspection and approval.

3.04 COPPER COMMUNICATIONS CABLE TESTING

A. General:

1. The Contractor must provide all instruments, materials and labor required for tests specified herein.

2. Tests conducted at the factory must include, but not be limited to, the following:

a. Manufacturer's standard tests.

b. Tests relevant to NEMA WC 7 that are not included in the manufacturer's standard tests. These tests include, but are not limited to, the following:

1) 6.4 Test Samples and Specimens for Physical and Aging Tests.

2) 6.6 Accelerated Water Absorption Tests.

3) 6.11 Tests for Discharge Resistance.

4) 6.12 Volume Resistivity.

5) 6.14 Voltage Tests.

6) 6.15 Insulation Resistance.

c. Cross-talk, throughput and capacitance tests.

B. Conditions for Tests: Prior to performing any cable testing, the Contractor:

1. Must have submitted cable testing procedures for the VTA's approval at least 45 days in advance of the testing. No testing must be performed unless the Contractor has the approved test procedures in hand.

2. Must have field tests scheduled in consultation with the VTA.

C. Witness Tests: The VTA, at their option, will witness complete testing on all cable installations.

D. Field Tests:

1. General: All cables must be subjected to Acceptance Tests as specified below to ascertain that the dielectric strength of the cable insulation has not been impaired during installation, that the connections and splices are properly made and to confirm the integrity of the cable system prior to energization. Tests must include continuity tests and insulation resistance tests.

2. Acceptance Tests: After installation of the entire length of a cable, the Contractor must perform the tests listed below on each cable. To preclude damage to equipment and devices, the tests must be conducted before the cable is terminated at the electrical equipment. If terminations have already been made, cables must be disconnected from the equipment for testing and must be reconnected after completion of tests.

a. Dielectric Test: This test must be performed to ensure that the cable insulation has not been impaired during installation.

b. Continuity Test: This test must be performed to prove the continuity of the conductor.

c. Insulation Resistance Test:

1) This test must be performed to determine the conductor to ground resistance and conductor to conductor resistance.

2) Tests must be conducted with a motor-driven megger. Test voltage must be applied between the conductor and ground and must be held until the reading reaches a constant value for 5 minutes. Insulation resistance values obtained by the megger tests must not be less than 2 MΩ. Contractor must bring to the attention of the VTA the results of similar tests having unequal readings with the variations of 25 percent or more.

3) For each test, record all data on approved test forms.

LAN, Data cables cross-talk, throughput and capacitance tests: Local area network cabling: The tests must include the use of a Category 6 cable tester capable of testing unshielded twisted pair (including the termination) up to a minimum of 100 MHz frequency. Tests must be performed in accordance with TIA/EIA 568 and the cable test set instructions.

d. Defective Cables: Any cable installed under this Contract found defective during the testing must be replaced with new cables at the expense of the Contractor.

3. OCS Disconnect Switch Cable: After required pre-installation cable testing, notify the VTA for turnover to Traction Power. Assist the VTA with final operational testing of the OCS monitoring systems as part of the System Integration test effort.

E.

3.05 FIELD QUALITY CONTROL

A. Quality: The quality of the system installation must be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications.

END OF SECTION

SECTION 27 15 23

FIBER OPTIC SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. Furnish, install, splice, and test all materials and equipment necessary to provide a complete and operable Fiber Optic System extension to the existing fiber optic network system. The new fiber optic cables shall be installed along Capital Expressway as shown on the plans.

B. The Fiber Optic System shall consist of fiber optic cables, branch cables, pre-terminated cables, splice enclosures, buffer tube fan-out kits, patch panels, patch cords, connectors, jumper cables, and all miscellaneous components for a fully functional system. The Contractor shall perform fiber continuity and attenuation testing after the complete system is installed and all splicing is completed. This shall also include fiber identification, labels and labeling, test results documentation and as-built drawings.

1.02 MEASUREMENT AND PAYMENT

A. Measurement: Fiber Optic System shall be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Fiber Optic System shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in constructing Fiber Optic System complete in place, as shown on the drawings, as specified in these Technical Specifications and as directed by the VTA, and no additional compensation will be allowed therefore.

C. Removal of SIC (Signal Interconnect Cable) as shown on the Plans is considered included in the lump sum price for Fiber Optic System.

1.03 QUALIFICATIONS

A. Due to the critical and complex technical requirements of this section, only those Contractors who can demonstrate that they possess the requisite knowledge, capabilities and experience with the equipment and materials being installed shall be allowed.

B. All technicians performing splices shall be certified as an Advanced Fiber Optics Technician or Certified Fiber Optics Specialist by the Fiber Optic Association (FOA). Contractor shall submit to the Engineer for approval proof of FOA certification for each of the technicians performing splicing.

C. All technicians testing cable shall be certified as an Advanced Fiber Optics Technician or Certified Fiber Optics Specialist by the Fiber Optic Association (FOA). Contractor shall submit to the Engineer for approval proof of FOA certification for each of the technicians performing testing.

D. Contractor shall submit to the Engineer for approval the resumes with references of people who will be performing splices along with proof of FOA certification. Splices shall be performed only by experienced personnel with experience including successful completion of no less than 2,000 fusion splices. Only those individuals approved by the Engineer shall be allowed to make fiber optic splices.

1.04 SUBMITTALS

A. Thirty (30) calendar days prior to anticipated construction of the fiber optic cable system, the Contractor shall provide all documentation pertaining to the materials and methods of execution proposed to satisfy the requirements of this Section. The Engineer's approval is required prior to the purchase of any materials or the commencement of any work.

B. The Contractor shall anticipate a minimum of 30 calendar days for approval of each submitted item. Actual time for the Engineer's review is dependent upon the completeness and appropriateness of the documentation being submitted. Any deficiencies will require additional time for approval. Any delays caused by such deficiencies will not be considered grounds for extension of project time.

C. The Engineer's approval of any submitted documentation shall in no way relieve the Contractor from compliance with the safety and performance requirements as specified herein.

D. A minimum of 60 calendar days prior to fiber cable installation, the Contractor shall submit a Fiber Pulling Plan for Engineer review and approval.

E. Document Fiber Cable Test Results for review by the Engineer and acceptance per the requirements of this Section.

F. Submit qualifications of fiber optic testing and splicing technicians per the requirements of this Section.

1.05 WARRANTY OF WORK

A. The Fiber Optic Cable System shall have a manufacturer- provided equipment warranty for a period of at least two (2) years.

B. Warranty period shall commence at Project Acceptance

C. Warranty work shall include materials, installation and construction products.

D. Contractor shall provide a contact name and phone number for warranty work

E. Response time for warranty work shall be within 48 hours

F. Contractor shall remove and replace any equipment components that fail during the warranty period.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Fiber Optic Cable System shall include the following cables and materials:

1. The Fiber Optic Cable (96 SMFO) which shall be used as mainline communication fiber cable installed along Capitol Expressway as shown on the plans.
2. Fiber Optic Patch Cords
3. Fiber Optic Connectors
4. Buffer Tube Breakout Kits
5. Rack-Mounted Fiber Optic Patch Panels

B. Fiber Optic Cable - Optical Fiber Characteristics

1. Each optical fiber shall be glass, manufactured by Corning or approved equal, and consist of a doped silica core surrounded by concentric silica cladding; and meet ITU-T G.625.D,"Characteristics of a single-mode optical fiber cable." All fibers in the buffer tube shall be factory tested and usable fibers, and shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of these Special Provisions.
2. Fiber coating shall be layered, UV cured, acrylate. The coating shall be mechanically or chemically strippable without damaging the fiber.
3. The required fiber grade shall reflect the maximum individual fiber attenuation, to guarantee the required performance of each and every fiber in the cable.
4. Each optical fiber shall be proof tested by the fiber manufacturer at a minimum of 100 kpsi.
5. Fiber optic strands within the finished cable shall meet the following requirements:

Fiber Optic Strands	
Property	**Requirement**
GEOMETRY	
Core Diameter	8.3 µm (nominal)
Cladding Diameter	125 µm ± 1.75 µm
Core to Cladding Concentricity	≤ 0.8 µm
Mode Field Diameter (Peterman II)	9.3 ± 0.5 µm at 1300 nm 10.5 ± 1.0 µm at 1550 nm
Coating Diameter	250 µm ± 15 µm
Cladding Non-Circularity Defined as: [1-(min. cladding Diam. / max. cladding diam.)]x100	≤ 1.0%
OPTICAL	
Type	Step Index
Attenuation @ 850 nm @ 1,300 nm @ 1,550 nm	 - ≤ 0.4 dB/km ≤ 0.3 dB/km
Attenuation at the Water Peak	≤ 2.1 dB/km @ 1383 + 3 nm
Chromatic Dispersion: Zero Dispersion Wavelength Zero Dispersion Slope	 1301 to 1321.5 nm ≤ 0.092 ps/(nm2*km)
Maximum Dispersion	3.3 ps/(nm*km) for 1285 - 1330 nm < 18 ps/nm*km) for 1550 nm
Cut-Off Wavelength	< 1,260 nm

6. The Contractor shall submit certification from the manufacturer that the above requirements have been met by the cable supplied for the project. Documentation of factory results shall be submitted to the Engineer with the *Cable Reel Acceptance Test* outlined in this Section.

C. Fiber Optic Cable – Construction

1. General:
   a. Fiber optic cable shall be a Corning Cable Systems Altos® cable or approved equal, being new and from the same manufacturer who is regularly engaged in the production of this material; and unless otherwise indicated in these Special Provisions, with optical fibers contained within loose buffer tubes that are stranded around an all dielectric central member in a reverse oscillation lay with aramid yarn as the primary strength member (with no armoring), a waterblocked core that is dry to the touch, and a polyethylene sheath for overall protection.
   b. The Contractor shall provide manufacturer's certification that the furnished cable is listed with the Rural Utilities Service (RUS) Specification 1755.900 as currently amended; and qualified to the Telcordia/Bellcore GR-20-CORE Issue #3 requirements as set forth in these Special Provisions. Any deviations from these provisions shall be conspicuously noted in the Contractor's submittal.
   c. The Contractor shall provide a cable with at least the fiber counts shown on the Plans.
   d. Fiber optic cable shall comply with the optical and mechanical requirements over an operating temperature range of -40ºC to +70ºC.

2. Color Coding:
   a. In buffer tubes containing multiple fibers, each fiber shall be distinguishable from others in the same tube by means of color coding. The colors shall be targeted in accordance with the Munsell color shades and shall meet EIA/TIA-598 "Color Coding of Fiber Optic Cables."

b. The color formulation shall be compatible with the fiber coating and the buffer tube filling compound and be heat stable. It shall not fade or smear or be susceptible to migration and it shall not affect the transmission characteristics of the optical fibers and shall not cause fibers to stick together.

3. Buffer Tubes
   a. All trunkline cables shall have twelve (12) fibers per buffer tube.
   b. The loose buffer tubes shall provide clearance between the fibers and the inside of the tube to allow for thermal expansion without restraining the fiber. The fibers shall be loose or suspended within the tubes. The fibers shall not adhere to the inside of the buffer tube.
   c. The loose buffer tubes shall be extruded from material having a coefficient of friction sufficiently low to allow the fiber free movement. Buffer tubes shall be made of tough abrasion resistant material to provide mechanical and environmental protection of the fibers yet designed to permit safe intentional "scoring" and breakout entry without jeopardizing the internal fibers.
   d. Buffer tube filling compound shall be homogenous hydrocarbon-based gel (with anti-oxidant additives) to prevent water intrusion and migration. The filling compound shall be non-toxic and dermatologically safe to exposed skin. It shall be chemically and mechanically compatible with all cable components, non-nutritive to fungus, non-hygroscope and electrically non-conductive. The filling compound shall be free from dirt and foreign matter and shall be readily removable with conventional non-toxic solvents.

4. Central Member: The central member which functions as an anti-buckling element shall be a glass reinforced plastic rod with similar expansion and contraction characteristics as the optical fibers. A linear overcoat of Low Density Polyethylene shall be applied to the central member of the main trunk fiber cable to achieve the optimum diameter to provide the proper spacing between buffer tubes during stranding.

5. Filler Rods: Fillers may be included in the cable to lend symmetry to the cable cross-section where needed. Filler rods shall be solid medium or high density polyethylene. The diameter of filler rods shall be the same as the outer diameter of the buffer tubes.

6. Stranding: Completed buffer tubes shall be stranded around the over coated central member using stranding methods, lay lengths and positioning such that the cable shall meet mechanical, environmental and performance specifications. A polyester binding shall be applied over the stranded buffer tubes to hold them in place. Binders shall be applied with sufficient tension to secure the buffer tubes to the central member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking, and dielectric with low shrinkage.

7. Core and Cable Flooding: The cable core interstices shall be filled with waterblocking tape or other method that is dry to the touch, to prevent water ingress and migration.

8. Tensile Strength Member: Tensile strength shall be provided by high tensile strength aramid yarns and fiberglass which shall be helically stranded evenly around the cable core.

9. Outer Jacket:
   a. The outer jacket material shall be a medium density polyethylene (MDPE) or high density polyethylene (HDPE) applied directly over the tensile strength members and water blocking material and shall not adhere to the armored strength material. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.
   b. The outer jacket or sheath shall be marked with the manufacturer's name, the words "Fiber Optic Cable", date of manufacture, and sequential meter markers. The markings shall be repeated approximately every three (3) feet. The actual length of the cable shall be within 0 ± 1 percent of the length marking. The marking shall be in a contrasting color to the cable jacket. The height of the marking shall be approximately 1/8”.
   c. The cable shall contain at least one ripcord under the inner sheath for easy sheath removal.

10. Pre-terminated Fiber Optic Branch Cable (12 SMFO): Factory pre-terminated fiber optic branch cable shall be furnished for County of Santa Clara communications and be a REALM Communications

Gorilla-Proof Distribution Unit (GPDU) RCG-GPDU-FC-12 or approved equal. The cable shall be of an appropriate length 12-strand pre-terminated fiber optic cable for installation between the mainline communication cable and the County traffic signal controller cabinet. The factory pre-terminated distribution panel shall be constructed of 16-gauge 304 stainless steel with stainless hardware, use FC fiber connectors that are qualified to Telcordia/Bellcore GR-326-CORE Issue #3 requirements, have two mountable faces, contain an integrated cover/mounting bracket that removes easily for full access without disturbing cable routing, and provide a protection shroud for fiber patch cord connectors.

11. Fiber Optic Patch Cords:
    a. Patch cords shall meet the same material specifications as those specified for Optical Fiber.
    b. Pre-assembled patch cords shall be purchased from the manufacturer completely assembled in standard lengths. Patch cords shall be supplied in lengths suitable for the installation requirements between patch panel and equipment.
    c. The outside jacket shall be color-coded yellow for single mode fiber.
    d. Pre-assembled fiber optic patch cords shall be labeled at each end, within six (6) inches of the termination. The label shall be identical at each end of the cord. Each cord shall have a unique label. Labels may be field applied.
    e. Unless a different connector is required for compatibility with existing or proposed active components, all fiber optic connectors shall be LC Duplex compatible with the requirements of the LC connectors specified in this Section.

12. Fiber Optic Connectors:
    a. Unless otherwise noted in the Plans, all fiber optic connectors used on this project shall meet the following:
        i. Shall be LC/UPC (55dB) Duplex connector in accordance with Telcordia GR-326
        ii. The LC connector shall be ceramic ferrule, with the fiber permanently secured within the ferrule by epoxy (heat set), chemically cured or a hot-melt adhesive in accordance with the connector and/or the epoxy manufacturer. When connectors are installed outside of a controlled-environment location, the connector minimum operating temperature range shall be -40 deg F to +158 deg F. For those applications within a controlled-environment location, the minimum operating temperature shall be -4 deg F to +140 deg F.
        iii. The procedure for the termination of connectors used in this project shall meet that set out in the connector manufacturer's standard operating procedure for field installation. This procedure shall be submitted to the Engineer for approval. Unless recommended otherwise by the connector manufacturer, each fiber shall be cleaved and cleaned, and shall receive multiple polishing with increasingly fine grit polishing pads.
        iv. The average loss for mated pairs of connectors shall not exceed 0.3 dB for single mode fibers.

13. Buffer Tube Fan-Out Kit:
    a. The Buffer Tube Fan-Out Kit shall meet the following requirements:
        i. The assembly shall include a 900 mm fan-out assembly and a top and bottom furcation unit.
        ii. The assembly shall be color coded to match the fiber color scheme.
        iii. The assembly shall have an environmental rating by the manufacturer for use in field cabinets.
        iv. The tubing supplied within the assembly shall have a minimum length of 25 inches.
        v. The assembly shall be sized for either 6 or 12 single-mode fibers. depending on the fiber optic cable that is to be terminated.
        vi. The Buffer Tube Fan-Out Kits shall be used within the communications cabinets to terminate the fiber distribution cables onto fiber optic connectors within the patch panels.

14. Rack-Mounted Fiber Optic Patch Panels
    a. The termination panels located in the communications cabinets shall consist of a rack-mountable single panel housing for storage, protection and termination of fiber optic drop distribution cables.
    b. The panel shall meet the following requirements:
        i. The patch panel housing shall be of corrosion resistant metal construction with dimensions no larger than 7”H x 17”Wx14”D.

ii. The patch panel shall be suitable for rack-mounting and shall be provided with all necessary hardware required.
iii. The patch panel shall be sized for each platform to accommodate all of the fibers that are to be terminated within the communications cabinet with a minimum of 24 ports.
iv. The patch panel cabinet shall include a lockable access door.
v. The panel shall have cable entrances on the top and bottom of the cabinet. All cable entrances shall have a gasket to prevent the ingress of foreign material into the cabinet.
vi. The cabinet shall include internal cable management for the protection of the furcated fibers.
vii. The patch panel shall utilize connector panels to facilitate the connection of the connectorized Buffer Tube Fan-Out Kit and fiber optic patch cords used to connect to the equipment.
viii. The patch panel housing shall accommodate and include connector panels that each accommodates up to 12 fibers. The connector panel shall be populated with six LC Duplex connectors. All connectors shall be supplied with protective covers.

2.02 FIBER OPTIC CABLE PERFORMANCE

1. General
   a. The fiber optic cable shall withstand water penetration when tested with three (3) feet static head or equivalent continuous pressure applied at one end of a three (3) feet length of filled cable for one hour. No water shall leak through the open cable end. Testing shall be done in accordance with EIA-455-82B, “Fluid Penetration Test for Filled Fiber Optic Cable.”
   b. The cable shall exhibit no flow (drip or leak) at 80º C. The weight of any compound that drips from the sample shall be less than 0.002 ounce. A representative sample of cable shall be tested in accordance with EIA-455-81A, "Compound Flow (Drip) Test for Filled Fiber Optic Cable". The test sample shall be prepared in accordance with Method A.
   c. Crush resistance of the finished fiber optic cables shall be 220 N/cm applied uniformly over the length of the cable without showing evidence of cracking or splitting when tested in accordance with EIA-455-25A “Repeated Impact Testing of Fiber Cables and Cable Assemblies”. The average increase in attenuation for the fibers shall be < 0.10 dB at 1550 nm (single-mode) for a cable subjected to this load. The cable shall not exhibit any measurable increase in attenuation after removal of load. Testing shall be in accordance with EIA-455-41A, "Compressive Loading Resistance of Fiber Optic Cable", except that load shall be applied at the rate of 3 mm to 14 mm per minute and maintained for 10 minutes.
   d. The cable shall withstand 25 cycles of mechanical flexing at a rate of 30 ± 1 cycles/minute. The average increase in attenuation for the fibers shall be <0.10 dB at 1550 nm (single-mode) at the completion of the test. Outer cable jacket cracking or splitting observed under 10X magnification shall constitute failure. The test shall be conducted in accordance with EIA-455-104A, "Fiber Optic Cable Cyclic Flexing Test," except that the sheave diameter shall be a maximum diameter of 20 times the cable outside diameter (OD). The cable shall be tested in accordance with Test Conditions I and III of the EIA-455.
   e. The cable shall withstand a tensile load of 2700 N without exhibiting an average increase in attenuation of greater than 0.10 dB (single-mode). The test shall be conducted in accordance with EIA-455-33, "Fiber Optic Cable Tensile Loading and Bending Test," using a maximum mandrel and sheath diameter of 560 mm. The load shall be applied for one hour in Test Condition II of the EIA-455 procedure.

2. Quality Assurance
   a. The Contractor shall submit certification from the manufacturer that the above requirements have been met by the cable supplied to the project. Documentation of factory results shall be submitted to the Engineer with the Cable Reel Acceptance Test outlined in this Section.
   b. Fiber optic cable shall meet or exceed the applicable provisions of the following documents as stated in this Section:

i. CFR, Title 7, Chapter XVII, Part 1755, Sec. 1755.900, RUS Specification for Filled Fiber Optic Cables
ii. ANSI/ICEA S-56-434-1983, Polyolefin Insulated Communications Cables For Outdoor Use, Reaffirmed October 18, 1991
iii. TIA/EIA-598-A, Optical Fiber Cable Color Coding (ANSI/TIA/EIA-598-A-95)
iv. TIA/EIA-455-28C, FOTP-28 - Method for Measuring Dynamic Tensile Strength and Fatigue Parameters of Optical Fibers by Tension (ANSI/EIA-455-28C-99)
v. EIA/TIA-455-82B, FOTP-82 - Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable (ANSI/EIA/TIA-455-82B-92)
vi. TIA/EIA-455-95, FOTP-95 - Absolute Optical Power Test for Optical Fibers and Cables
vii. EIA-359-A-1, Colors for Color Identification and Coding (See ANSI C83.1)
viii. EIA/TIA-455-81A, FOTP-81 - Compound Flow (Drip) Test for Filled Fiber Optic Cable (ANSI/EIA/TIA-455-81A-91)
ix. TIA/EIA-455-25B, FOTP-25 - Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies (ANSI/TIA/EIA-455-25B-96)
x. TIA/EIA-455-41A, FOTP-41 - Compressive Loading Resistance of Fiber Optic Cables (ANSI/TIA/EIA-455-41A-93)
xi. TIA/EIA-455-33A, FOTP-33 - Fiber Optic Cable Tensile Loading and Bending Test (ANSI/EIA-455-33A-87)
xii. TIA/EIA-455-104A, FOTP-104 - Fiber Optic Cable Cyclic Flexing Test (ANSI/TIA/EIA-455-100A-89, R99)

2.03 FIBER OPTIC CABLE PACKAGING AND SHIPPING

A. The completed cable shall be packaged for shipment on lagged wooden reels. The cable and reel shall be wrapped in water resistant covering. The cable reels shall always be stored in an upright position and never stored lying on their sides.

B. Each end of the cable shall be securely fastened to the reel to prevent the cable from coming loose during transport. Six (6) feet of cable length on each end of the cable shall be accessible for testing. Both ends of the cable shall be sealed to prevent the ingress of moisture.

C. Delivery Inspection: The Contractor shall inspect fiber optic cables at the time of delivery to the Site to ensure that no damage was done during shipping and that the specified cable was received. Every reel shall be inspected by the Contractor for physical damage such as nails driven into reels to secure shipping blocks, lagging, or reel covering missing and cable and seals missing or damaged. A copy of these inspection reports shall be submitted to the Project Engineer when requested. The Contractor shall replace all damaged or rejected cable promptly.

D. Factory Tests: Prior to shipment, Factory-controlled tests shall be performed to verify compliance of the cable with these specifications. Each cable reel shall be shipped with test results indicating the length of the cable reel and the attenuation at 1310 nm and 1550 nm for each fiber. A copy of these test results shall also be provided to the Engineer. Any test that reveals the materials or equipment does not meet the stated specifications shall constitute failure.

E. Each cable reel shall have a durable weatherproof label or tag showing the following:

1. Manufacturer’s name
2. The cable type
3. The actual length of cable on the reel
4. The Contractor’s name
5. The contract number
6. The reel number

F. A shipping record shall be included in an attached weatherproof envelope showing the above information and shall include the date of manufacture, factory test cable characteristics (size, attenuation, etc.), cable information number and any other pertinent information.

G. The diameter of the reel shall be at least thirty times the diameter of the cable. The fiber optic cable shall be in one continuous length per reel with no factory splices in the fiber. Each reel shall be marked to indicate the direction the reel should be rolled to prevent loosening of the cable.

PART 3 - EXECUTION

3.01 EXAMINATION

A. All cables and connectors shall be visibly inspected before installation to ensure that there are no cuts, nicks or other visible degradation to the cable.

3.02 INSTALLATION

A. All cable installation work shall be carried out in accordance and consistent with the highest standards of quality and craftsmanship in the communication industry with regard to the electrical and mechanical integrity of the connections, the finished appearance of the installation, as well as the accuracy and completeness of the documentation.

B. The Contractor shall make a physical survey of the project site for the purpose of establishing the exact cable routing and cutting lengths prior to the commencement of any fiber optic work or committing any fiber optic materials. The Contractor shall submit a cable routing plan that shows the location of any splices, and fiber optic insertion and pulling points.

C. Cables shall be installed in outdoor cabinets, conduits, vaults and junction boxes as shown in the Plans.

D. In each pull box where a fiber optic cable is installed provide fiber slack as shown in the drawings.

E. During cable installation, the bend radius shall be maintained at a minimum of twenty times the outside diameter of the cable or per the manufacturer’s recommendations and standards. In all pull boxes, the cable shall be routed as needed to avoid violating the minimum-bending radius. After installation, the bend radius shall be maintained at a minimum of ten times the outside diameter of the cable or in compliance with the manufacturer’s recommendations and standards .

F. During installation the Contractor must keep a log that notes the meter marking on the cable at every pull box. This will help determine the exact location of problems along the cable run during the testing. The log shall present the information in sequential order and in table format listing the street and distance to the nearest cross street. This log shall be submitted to the Engineer after all the fiber optic cable has been installed and before performing any fiber optic cable testing.

G. Fiber installation shall be done in accordance with industry standards BISCI and NECA/FOA 301-2009.

H. A dynamometer shall be used for all pulling operations.

I. Maximum pulling tensions for cable pulled in conduit shall not exceed 2700N (600 lbs.) or amount specified by cable manufacturer. A 2700N (600 lb.) breakaway swivel shall be used on all underground cable pulls.

J. Where feasible, continuous cable pulls shall not be made through more than one 90 degree bends or more than a total of 180 degrees in conduit bends. However, when this is not possible, the cable pull shall be monitored to ensure that the pulling tension shall not exceed 2700N (600 lbs) or the amount specified by the manufacturer.

K. The cable will be continuous between stations and/or splices as indicated on the Plans. The Contractor shall not cut the cable to aid in installation, unless approved in writing by the Engineer. At locations where selective splicing is required, only those fibers spliced to local drop or branch cables may be severed in the main fiber optic cable run.

L. The use of a factory installed pulling eye is preferred, however a Kellum grip is acceptable for pulling cable through conduit. It is recommended that the central strength member and/or kevlar be woven into and secured onto the grip on these pulls.

M. Cable lubrication shall be used to reduce pulling tension on longer segments of the cable placement operation. Only approved pulling lubricants shall be used.

3.03 FIBER OPTIC SPLICING

A. The Contractor shall keep accurate record of each new splice at each splice location.

B. The fiber optic cable splices shall be fusion type. The maximum allowable splice loss shall not exceed 0.1dB.

C. All splices shall be tested in accordance with the fiber testing specified in this Section.

D. Splices shall be housed in a splice tray in a splice enclosure in an underground pull box. All splices shall be protected with a thermal shrink sleeve. The Contractor shall perform all outdoor splices within a tent, truck or trailer. If the Contractor wishes to use another type of facility for splicing, it must be approved by the Engineer on a day-by-day basis.

E. Only those fibers that are to be spliced shall be removed from the cable and buffer tubes. All other fibers shall remain in their tubes and shall be suitably protected. The Contractor shall seal all cables where the cable jacket is removed. The cable shall be sealed per the cable manufacturer's recommendation with an approved blocking material.

F. Vehicles used for fiber splicing shall have their engine turned off during splicing.

3.04 FIBER OPTIC CABLE TESTING

A. General:

1. Contractor acknowledges that contractor-performed testing is a vital component of the work and required for beneficial use of the improvement. All testing shall be performed in a manner that provides the time, space, set up, tools, and equipment for the Engineer to inspect and verify all tests, including review of fiber connections, test equipment, device displays, and documentation for each fiber and test set up. The tests shall quantitatively demonstrate that the fiber optic cable meets the requirements of these Special Provisions and Project Plans.

2. Testing the installed fiber optic cable plant shall be done according to *FOA Standard FOA-1: Testing Loss of Installed Fiber Optic Cable Plant*."

3. Vehicles used for fiber testing shall have their engine turned off during testing.

B. Test Plan

1. The Contractor shall develop and submit a test plan to the Engineer for review that outlines the steps required and schedule to test the fiber optic cables.

2. If the Engineer rejects the test plan, the Contractor shall submit a revised test plan within five (5) working days for review and approval by the Engineer. No testing shall be performed until Contractor's test plan has been approved by the Engineer.

3. The Contractor shall notify the Engineer of his intent to proceed with testing forty eight (48) hours prior to commencement of each test.

C. Cable Reel Acceptance Test

1. The Cable Reel Acceptance Test shall be performed within five (5) workings from the time the fiber optic cable is received from the supplier. Only one direction needs to be tested with an Optical Time Domain Reflectometer (OTDR). This test is intended to verify that the fiber received from the supplier

is in sound condition and without manufacturing defects. Fiber optic cable that does not meet the requirements of this Section shall be replaced at no additional cost.

2. At the time of testing, the Contractor shall inspect the fiber optic cable and record any visible signs of defects. The Contractor shall note any anomalies on the test results and rescale the OTDR scale for clarity and record. Any anomalies shall be reported immediately to the supplier/manufacturer. The Contractor shall also note any differences between the 1550nm trace and the 1310nm trace. The Contractor shall compare the test results to the manufacturer's specifications and factory test results provided with the cable reel and note any discrepancies. The Contractor shall install heat shrink or other protective covering to the cable end to prevent the entry of moisture or other contaminants.

3. Test results shall be summarized on a form.

D. Cable Installation Acceptance Test

1. The Cable Installation Acceptance Test shall be performed as described in the Cable Reel Acceptance test, except the Installation Test is conducted from both ends of the fiber optic cable. The Installation Test shall be performed within five (5) workings from the time the fiber optic cable is installed, and before splices or connectors are added.

2. In addition to the requirements outlined under the Cable Reel Acceptance Test, the Contractor shall note the differences in measurements taken from opposite directions.

3. Test results shall be summarized on a form.

E. Final Acceptance Test

1. The Final Acceptance Test shall be conducted from both ends of the fiber optic cable within five (5) working days after all splices have been installed to evaluate total end-to-end loss, splice and connector loss and backreflection, and overall reflectance levels. The end-to end Final Test shall consist of performing OTDR testing; including optical loss and reflection testing with an optical loss test set (OLTS).

2. Test results shall be summarized on a form.

F. Acceptance Test Documentation

1. All test results, including results of failed tests or re-tests, shall be submitted and delivered to the Engineer.

2. The test results shall be organized in the following manner:
   a. A three-ring binder shall be created to contain all Factory Tests, Cable Reel Acceptance tests, including OTDR fiber trace printouts and test summary forms, and shall be organized by Reel ID.
   b. A three-ring binder shall be created to contain all Cable Installation Acceptance tests, including OTDR fiber trace printouts and test summary forms, and shall be organized by fiber optic cable segments.
   c. A three-ring binder shall be created to contain all Final Acceptance tests, including all fiber trace printouts and test summary forms, and shall be organized with end-to-end test locations grouped together.

3. All trace printouts shall bear the signature or initials of the Contractor's representative who has reviewed the traces. The Contractor shall place a check mark on all traces that satisfy the requirements identified herein. The Contractor shall highlight any discrepancies that may exist in the test results by placing a post-it flag on the subject page. The page shall bear a short description of the proposed corrective action (i.e., resplice), which must be approved by the Engineer prior to implementation. Upon Contractor's submission of a complete test result packet containing all required documentation indicated herein, comments will be provided within twenty (20) working days. Any subsequent retesting, resplicing, or revision of documentation shall be at no additional cost.

4. All trace printouts shall contain the following:

a. Maximum specified loss at specified wavelengths
b. Date and time of test
c. Test Crew
d. Test Equipment model and s/n
e. Direction of measurement
f. Length of trace.
g. Buffer tube and fiber color.

G. Electronic Trace File Names

1. Every trace associated with a test shall be saved on Compact Disc (CD) media and archived for submittal to the Engineer. The Contractor shall supply a licensed software package to read, store, compare, and analyze the electronic data files created by testing instruments. The electronic files shall be organized as follows:
   a. Reel acceptance test OTDR files shall be saved in a sub-folder named after the Reel ID.
   b. Installation acceptance test OTDR files shall be saved in a sub-folder named after the cable segment.
   c. Final acceptance test files shall be saved in a sub-folder named after the end-to-end location.
   d. Files names shall have a logical and consistent format such as follows:

Date Code
Fiber No.

RAT#XX-XXX-mmddyy

RAT (Reel Acceptance Test) - Reel ID
(e.g. RAT#02-001-042113)

Date Code
Test Location
(Beg Pt. to End Pt.)
Fiber No.

IAT-XXX-XXXXX to XXXXX-mmddyy

IAT (Installation Acceptance Test)
(e.g. IAT-001-10&SC_to_AR&King-061813)

FAT (Final Acceptance Test) - End-to-End Location

FAT-XXXXX_to_XXXXX-mmddyy

Test Location
(Beg Pt. to End Pt.)
Date Code

(e.g. FAT-10&SCFO38_to_AR&CapFO38-081213 for the end to end location from 10th & Santa Clara to Alum Rock & Capital Ave)

e. Filename extensions shall be consistent and recognized by the licensed testing software package.
f. All files and folders shall be backed up onto CD or flash drive daily, and immediately submitted to the Engineer.

H. Optical Loss Test Set Equipment

1. The OLTS shall consist of a light source and power meter that meets the following minimum requirements.
   a. Single mode optical fiber light source:
      1) Provide dual laser light sources with central wavelengths of 1310 nm (±20 nm) and 1550 nm (±20 nm).
      2) Output power of –10 dBm minimum.
   b. Power Meter:
      1) Provide 850 nm, 1300/1310 nm, and 1550 nm wavelength test capability.
      2) Power measurement uncertainty of ± 0.25 dB.

I. OTDR Test Equipment

1. The OTDR used shall be provided with certification of its most recent calibration which shall be within twelve (12) months from the date of the testing.

2. The OTDR operator shall hold a current operators certificate for the equipment used. This certificate shall represent not less than 16 hours of training from the equipment manufacture. This certificate shall be presented to the Engineer at the start of testing.

3. The OTDR shall have a distance measurement accuracy of ± 0.01% and meet the following minimum requirements.

4. Single mode OTDR
   a. Wavelengths of 1310 nm (± 20 nm) and 1550 nm (± 20 nm).
   b. Event dead zones of 2 m maximum at 1310 nm and 2 m maximum at 1550 nm.
   c. Attenuation dead zones of 15 m maximum at 1310 nm and 15 m maximum at 1550 nm.
   d. Distance range not less than 10,000 m.
   e. Dynamic range at least 10 dB at 1310 nm and 1550 nm

5. Testing Requirements
   a. All test measurements shall be measured at the wavelengths outline under section 86-2.20A, "General Fiber Optic Cable Characteristics," of these special provisions.
   b. A 1,000 meter launch cable, or launch box, shall be used to overcome the dead zone of the OTDR inserted between the OTDR and the optical link.
   c. The OTDR testing shall be done at a scale of at least 1 dB per division on the vertical scale.
   d. Contractor shall perform tests to verify that ports and fibers installed by others have end points indicated in the plans.
   e. The Contractor shall perform all fiber optic testing in the presence of the Engineer and/or City Inspector. Any testing performed by the Contractor and not witnessed by the Engineer and/or Inspector shall not be accepted; and thus, re-testing shall be performed at no cost to the City.
   f. Splice insertion loss shall not exceed 0.1dB mean (0.3dB maximum) as specified in TIA/EIA-758, "Customer Owned Outside Plant Telecommunication Cabling Standard," when measured in accordance with ANSI/ TIA/EIA-455-8, "Measurement of Splice and Connector Loss and Reflectance Using an OTDR."

3.05 FIBER OPTIC CABLE LABELING AND PATH MARKING

A. Fiber Optic Cable Labeling

1. The fiber optic cable shall be clearly marked with a permanent plastic orange tag in each pull box it passes through as well any field cabinet. The following information shall be placed on the tag with waterproof black ink:
   a. The labeling format for mainline cables shall conform to the following:

County of Santa Clara (CSC) or VTA
XXF – SM Trunkline

total # of fibers in mainline cable

XXXX - XXXX / XXXX

Trunk Begin Splice **Trunk End Splice** **Main St**
Agency Name
Contact Phone Number

For example, a 48-strand fiber optic cable installed on Alum Rock Avenue at 33rd Street would be labeled:

   b. CSC – Alum Rock Trunk
   c. 48F – SM Trunkline
   d. 10th Street – 28th Street / Santa Clara
   e. County of Santa Clara
   f. (408) xxx-xxxx

2. Contractor shall submit a request to the Engineer for the contact phone numbers that will be contained on the label
   a. Permanent Fiber Optic Cable Path Markers
   b. Regardless of the method of installation, all new and existing conduits containing fiber optic cable shall be marked with permanent, above-ground, fiber optic markers.
   c. Permanent markers shall be installed no later than five (5) working days after the restoration of surface areas along the fiber optic cable path; and where no pavement restoration is required, ten (10) working days after the fiber optic cable is installed. Permanent fiber optic cable markers shall be installed on the cover of each pull box containing fiber optic cabling and within on and a half (1.5) feet along the fiber optic cable conduit path, spaced no more than six hundred (600) linear feet apart from each other. Permanent markers shall be installed at every junction where the conduit path changes more than 30 degrees. Where the conduit crosses any roadway, light-rail track, railroad tracks, or bridge structures, permanent markers shall be installed on both sides of the crossing.
   d. Permanent flexible line markers for unpaved areas shall be FlexPost by William Frick & Company or equal. These markers shall be four (4) feet in height above ground and installed with approximately one (1) foot underground. The flexible line markers shall be bright orange in color in accordance with the APWA national color code, and be formulated for above ground use under all weather conditions.
   e. Permanent markers for pull box covers and paved areas shall be Duracast® das Curb Markers by das Manufacturing or equal. The marker shall be circular in shape, two and a half (2-1/2) inches in diameter, bright orange in color (in accordance with the APWA national color code), and made from high-impact plastic, bright reflective material with UV resistant coatings and imprinting.

Markers shall be mounted flush with the surrounding surface. The markers shall have non-skid surfaces, and shall be secured per manufacturer recommend product or adequate anchorage approved by the Engineer to prevent removal of the marker.

3.06 PATCH CORD INSTALLATION

A. At no time shall the bending radius of a cord exceed the manufacturer recommendation. Patch cord installation shall meet the requirements specified in this Section for fiber cable testing and installation.

B. All patch cords longer than 100 feet shall be tested using an Optical Time Domain Reflectometer (OTDR). OTDR testing shall occur after completion of the installation, splice, or termination.

C. Patch Cords installed within a cabinet shall adhere to the following:

1. Patch cords contained within a patch panel shall not be more than 1 foot longer than required to make the connection.
2. Patch cords between two patch panels shall not be more than 1 foot longer than required to make the connection.
3. Patch cords between a patch panel and a device shall not be more than 2 feet longer than required to make the connection.
4. Patch cords between a patch panel and a device shall be contained inside of ½" or 3/8" split yellow loom.
5. Boots shall be glued to the jacket of the patch cord.

3.07 FIBER OPTIC INSTALLATION CLOSE-OUT

A. The Contrator shall submit fiber optic as-builts for the fiber optic system specified in this section and as shown on the plans. The as-built documentaton shall be in a machine readable format and shall utilize OSP-Insight or an Approved Equivalent.

B. The Contractor shall register all fiber optic cable runs for the project with USA North at http://www.usanorth.org.

END OF SECTION 27 15 23

SECTION 27 21 00

COMMUNICATIONS NETWORK EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes requirements for:

1. The CTS SCADA 10 Gigabit Ethernet WAN Network equipment and software as specified.

2. The CTS Information Technology (IT) 10 Gigabit Ethernet WAN Network equipment and software as specified.

3. The Station SCADA 1 Gigabit (all ports, uplinks and LAN ports) LAN Network and Station Information Technology 1 Gigabit (all ports, uplinks and LAN ports) LAN Network equipment and software to be provided and installed at the Communications Nodes.

4. Hardened 1 Gigabit (all ports, uplinks and LAN ports) Mbps Access Switches, consisting of SCADA IP LAN Switches, and IT IP LAN Switches.

5. Network Management System (NMS) modifications.

6. Communications media converters, adapters, and transceivers.

1.02 RELATED SECTIONS

A. Section 27 05 00, Common Work Results for Communications

B. Section 27 05 28, Pathways for Communications Systems

C. Section 27 11 16, Communications Cabinets, Racks, Frames and Enclosures

D. Section 27 11 19, Communications Terminal Blocks and Patch Panels

E. Section 27 13 00, Communications Network Cabling

F. Section 27 15 00, Communications Low-Voltage Conductors and Cables

G. Section 27 26 00, Communications Programming and Integration Services

H. Section 27 30 00, Telephone System

I. Section 27 42 19, Public Address System

J. Section 27 42 20, Passenger Information Monitor System

K. Section 28 20 00, Video Surveillance (CCTV)

L. Section 28 31 00, Intrusion Detection System (IDS)

M. Section 28 40 00, SCADA Monitoring and Control System

N. Section 34 54 00, Automated Fare Collection

1.03 REFERENCES

A. The latest versions of the following standards and references apply to the work included in this Section, in addition to those codes and standards common to all communications subsystems specified in section 27 05 00, Common Work Results for Communications. If a conflict must arise between various standards, the California state code amendments must govern, or the most strict/conservative requirement must govern.

B. Electronics Industries Association (EIA)/Telecommunications Industry Association (TIA):

1. TIA/EIA-455-B Standard Test Procedure For Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components

2. ANSI/TIA/- 606-B Administration Standard for Commercial Telecommunications Infrastructure

C. Institute of Electrical and Electronic Engineers, Inc. (IEEE):

1. IEEE 802.3 Carrier Sense Multiple Access with Collision Detection Access Method and Physical Layer Specifications

D. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code

2. NFPA 262 Standard Method of Test for Fire and Smoke Characteristics of Wires and Cables

E. Underwriters Laboratories (UL):

1. UL 94 Standard for Safety of Flammability of Plastic Materials for Parts in Devices and Appliances testing

2. UL 910 Test for Flame-Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air

3. UL 1581 Standard for Safety Electrical Wires, Cables and Flexible Cords

4. UL 1666 Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts

1.04 QUALITY ASSURANCE

A. Manufactures of all CCS LAN equipment must be registered and compliant with ISO 9001.

B. Contractor must ensure that products are manufactured by firms regularly engaged in manufacturing products described in this Contract Specifications Section.

1.05 SUBMITTALS

A. The Contractor must submit the following as part of the Hardware Preliminary Design Review submittal package:

1. Description and model numbers, shop drawings, catalog cuts, and technical literature describing all of CCS LAN with WAN interface, and Station LAN equipment including the following:

a. Station distribution Ethernet LAN Switches

b. Station access Ethernet LAN Switches

c. Station edge Ethernet LAN Switches

d. All corresponding LAN/WAN Miscellaneous Equipment (e.g. device servers, media converters, fiber and copper patch panels, etc.)

2. Detailed CCS SCADA Ethernet LAN, WAN interface; and Station SCADA and IT Network LAN equipment block diagrams with physical interconnections and interfaces.

3. Identification and description of all external interfaces.

4. Description of all LAN and data communications facilities provided to implement fault tolerance and availability requirements.

5. Description of LAN and VLAN segmentation; IP addressing and security scheme; description of facilities to provide for security of the CCS.

6. Description of all LAN and WAN equipment Mean Time Between Failure (MTBF) from the manufactures.

B. As part of the Final Design Review submittal package, submit:

1. Updated versions of all previously submitted materials.

2. LAN network configuration diagrams showing the LAN/WAN system, diagrams of the LAN, and detailed cable drawings, schematics and equipment and I/O wiring diagrams for each location.

3. Communication equipment final layout diagrams showing communication equipment in each cabinet/room (e.g. conduits routing, grounding, cable management; racks layouts and rack interconnections, etc.).

4. Bills of materials for all network equipment and accessories.

5. If changes to the existing NMS, or other network equipment are required in the field or at central, submit the proposed new configuration.

C. Cutover Plan: Prior to the cutover the existing SCADA Ring 2 and IT Ethernet Loop E, the Contractor must submit for VTA approval a detailed plan specifying the details of the cutover procedure, the equipment involved, expected downtime and contingency procedures if the cutover does not go as planned.

D. Test Procedures:

1. The Contractor must submit a test plan and all detailed test procedures for the VTA approval. As a minimum, the test plan and procedures must meet the testing requirements found in Section 3 below.

2. Prior to the cutover, the Contractor must perform local testing of the station new LAN/WAN equipment first. The Contractor must proceed with the cutover only after the successful completion of the local tests.

3. After the successful cutover, the Contractor must complete the remaining testing.

4. All tests must be witnessed and signed by the Contractor and VTA representative.

E. As-Built Documentation: As part of the Communications System As-built documentation, include:

1. The as-built layout diagrams showing communication equipment in each cabinet/room with conduits routing, grounding, and cable management; detailed cable drawings, schematics, equipment, wiring.

2. All equipment configuration settings for the equipment provided or updated as specified in this section.

3. Manuals for the equipment specified in this section.

4. Manufacturer maintenance contract options with prices to VTA for choice and approval and manufacturer warranty documentation and/or maintenance contract for all network equipment provided as specified in this section.

5. All witnessed (and signed by VTA) test sheets included with test procedures in test reports.

1.06 MEASUREMENT AND PAYMENT

A. Measurement: Communications Low-Voltage Conductors and Cables must be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Communications Low-Voltage Conductors and Cables must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in this Section complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. System Description

There are 6 Station LANs required for this project, 3 for SCADA and 3 for IT, for each new LRT Light Rail Station node. The 3 LAN networks are distribution, access and edge level networks. Distribution (10 Gbps) networks connect directly to access (1 Gbps) networks and edge (1 Gbps) networks, access and edge networks do not connect directly together, they go through the distribution network. The backbone or distribution network is a longitudinal network along the guideway in the combined system ductbank, and terminates only at Station network nodes, and provides WAN connections between distribution LANs at stations, and VTA central facilities, connecting through existing station fiber optic rings (SCADA) and loops (IT). A ring is essentially equivalent to a loop, the naming is only to distinguish between SCADA and IT.

There are two primary SCADA LAN Switches (distribution, access) and two primary IT LAN Switches (distribution, access) at each passenger station, these switches are in the station equipment communications/signal room and IT room. One of the pair of switches is a 10 Gbps fiber optic distribution switch, the other is local 1 Gbps copper access switch (connected via dual 10 Gbps fiber optic uplinks to the fiber optic distribution switch). Both distribution and access types of switches are located within the Communications (SCADA), and Communications (IT) rooms. In addition, there are numerous edge switches for both SCADA and IT at each station, remotely located near related field equipment, which connect directly to the fiber optic distribution switch via dual fiber optic uplinks.

The three sets of LAN switches (distribution, access and edge) and associated connections and components, comprise the SCADA Station LAN and IT Station LAN.

An existing SCADA supervisory control system, public address, and supporting passenger station systems are in place, and includes WAN/LAN and computing equipment used to operate the existing Guadalupe, Tasman West/East, Capitol and Vasona LRT corridors, primarily consisting of passenger stations, TPSS substations, and elevated guideway. Existing equipment is located in the OCC, and central Equipment Room.

An existing IT/Admin network is in place, for security/CCTV, electronic display signs (PIMS), and fare collection card interface devices (CID).

The Contractor must update the existing configuration to accommodate the new Ethernet interfaces from the new Capitol Expressway corridor stations and the associated equipment.

B. General

1. The SCADA Ethernet LAN must provide data communications interfaces to the new equipment monitored and controlled by CCS, as well as to other VTA systems.

2. The IT Ethernet LAN must provide data communications interfaces to the new equipment monitored and controlled by the existing IT network at VTA Rail Operations Facility Disaster Recovery Room and existing VTA Administrative Facility Data Center, as well as to other VTA systems.

3. All Communications Nodes must include a Station SCADA distribution, access, and edge Local Area Networks (LAN) services by multiple SCADA Ethernet switches. The Station SCADA LANs must communicate to the CCS via the Cable Transmission Systems (CTS) Wide Area Network (WAN) connection. Network traffic must be segmented by station and function using SCADA Ethernet switches and routers.

4. Connections between the SCADA CTS OCC Ethernet interfaces and the station SCADA switches must be made in a manner to provide for continued LAN operation in the event of a single fault.

5. Connections between the Disaster Recovery Center and VTA Administrative Facility ethernet interfaces and the station IT switches must be made in a manner to provide for continued LAN operation in the event of a single fault.

6. The station LAN distribution, access and edge switch ports connecting the field devices to the head-end equipment in must be configured in separate Virtual Local Area Networks (VLANs) as established in the existing VTA network. VTA will supply the subnet schema and VLAN assignment during the Final Design Review. The final VLAN and IP addressing schema input from VTA must be included in the Final Design by the contractor, and must be approved by VTA.

7. Note that the IT Maintenance Telephones (MT), and IT Emergency Telephones (ETEL) are POTS lines and do not connect to the VTA ethernet networks, but connect to AT&T directly through individual POTS lines through the AT&T PSTN network.

8. Note that the 2nd line of the SCADA Maintenance Telephone is an analog line, and does not connect to the VTA ethernet networks, but connects only as a mixing input to the public address mixer for local station PA announcements.

9. There must be no loss in the existing functionality of the existing VTA SCADA or VTA IT Ethernet Networks as a result of the Contractor installations/modifications under the current project. It is the Contractor's responsibility to provide fully functional and fully integration with the existing VTA SCADA and VTA IT Ethernet Network equipment and connected systems.

C. Existing VTA Network

1. The existing VTA network consists of multiple SCADA rings, and multiple IT loops.

2. The SCADA rings utilize Cisco Catalyst 3760 10 Gigabit Ethernet distribution level switches with fiber optic uplinks connected in a folded, staggered fiber optic topology.

3. The IT loops utilize Allied Telesis 1 Gigabit Ethernet distribution level switches connected in a folded staggered loop fiber optic topology, and Cisco Catalyst 3850 1 Gigabit Ethernet access level switches for CCTV.

D. SCADA Distribution LAN

1. The Contractor must provide at each new EBRC/Capitol Expressway corridor station a SCADA 10 Gigabit (Gbps) distribution level Local Area Network (LAN) that uses 10 Gbps redundant connections from the new LRT stations to the existing network at adjacent station Alum Rock, then to the core network at the VTA Rail Operations Facility. The distribution Station LAN network equipment must be implemented in manner consistent with implementation of the existing similar equipment at existing stations. The distribution Station LAN must provide data communications interfaces to equipment monitored by CCS, as well as to other VTA systems via the Cable Transmission System (CTS) wide area network connection. The wide area connectivity to the CCS VTA Rail Operations is through the redundant fiber optic ring with all station nodes connected via folded, staggered topology to the ring 2 core node at the VTA Rail Operations Facility. The SCADA 10 Gigabit Station LAN distribution Ethernet Switch connects directly to local station edge level LAN remote equipment that utilizes dual 1 Gbps fiber optic connections. Distribution local SCADA LAN dual 1 Gbps fiber optic connections include but are not limited to:

   a. SCADA Intrusion Detection System Cabinet (IDS) IP edge Switches

   b. Elevator SCADA Enclosure (ELS/IDF) IP edge Switches

   c. TPSS SCADA Enclosure IP edge Switches

   d. Signals Case SCADA IP edge Switches

2. The distribution level Station LAN switch typically does not connect directly to station equipment requiring copper ethernet ports, but does so through a second SCADA switch, the access Station LAN switch.

E. SCADA Access LAN

The Contractor must provide at each new EBRC/Capitol Expressway corridor station a SCADA 1 Gbps access level Local Area Network, connecting directly to station communications devices with 1 Gbps copper ports. The access level LAN switch connects via dual fiber optic 1 Gbps uplinks to the distribution level Station LAN switch. Access SCADA 1 Gbps LAN connections include:

1. Signal System equipment such as Vital Processors (VP), Non-Vital Processors, TWC, CTP/VPI and EVR serial devices via the Communications Hub. The signal system provides the Communications Hub at each station, which will convert serial data communications streams into the Ethernet traffic to be passed to the new station access LAN switch:

   a. Signal system processors such as VPs, NVP's, CTPs, Event Recorders, and TWCs to allow supervision of the signal system through the CCS. Signal system processors communicate using serial data communications interfaces. To interface these serial devices with the new stations' LAN, the signal system provides, at each station a new Communications Hub (a.k.a Device Server or Terminal Server) equipment, which will convert serial data communications streams into the Ethernet traffic to be passed to the new station LAN switch.

2. Public Address Equipment Controller, Mixer and Power Amplifier

3. Rack Power Distribution Unit (PDU)

4. Rack Environmental & Security Monitoring Unit (ESMU)

5. Rack Uninterruptible Power Supply (UPS) remote access

6. One of the two lines of the SCADA Maintenance Telephones via SIP/VoIP adapters

7. VoIP SCADA Maintenance Telephones

8. Operator Break Room VoIP Telephones

F. SCADA Edge LAN

The Contractor must provide at each new EBRC/Capitol Expressway corridor station multiple SCADA 1 Gbps edge level Local Area Network Switches, connecting directly to station communications devices with 1 Gbps copper ports. The edge level LAN switch connects via dual fiber optic 1 Gbps uplinks to the distribution level Station LAN switch. Edge SCADA LAN switches include but are not limited to:

1. SCADA Intrusion Detection System Cabinet (IDS) IP edge Switches: to IDS Remote I/O and Infrared sensors

2. Elevator SCADA Enclosure (ELS/IDF) IP edge Switches: to Elevator Remote I/O

3. TPSS SCADA Enclosure IP edge Switches: TPSS PAC and VoIP MT

4. Signals Case SCADA IP edge Switches: to Signals EMSU and VoIP MT

G. Information Technology (IT) Distribution LAN

The Contractor must provide at each new EBRC/Capitol Expressway corridor station an IT 10 Gigabit (Gbps) distribution level Local Area Network (LAN) that uses 10 Gbps redundant connections from the new LRT stations to the existing network at adjacent station Alum Rock, then to the core network at the VTA Rail Operations Facility and VTA Administrative facility. The distribution Station LAN network equipment must be implemented in manner consistent with implementation of the existing similar equipment at existing stations. The distribution Station LAN must provide data communications interfaces to equipment monitored by VTA, as well as to other VTA systems via the Cable Transmission System (CTS) wide area network connection. The wide area connectivity to these central facilities is through the redundant fiber optic loop E, with all station nodes connected via folded, staggered topology to the loop E aggregation node B, then to Rail Operations and VTA Administrative facility. The IT 10 Gigabit Station LAN distribution Ethernet Switch connects directly to local station edge level LAN remote equipment that utilizes dual 1 Gbps fiber optic connections. Distribution IT LAN dual 1 Gpbs fiber optic connections include but are not limited to:

1. IT Intrusion Detection System Cabinet Switches (IDS)

2. Elevator IT IP edge Switches

3. TPSS IT Enclosure IP edge Switches

4. Station IDF IT IP Switches

5. TVM IDF IT IP Switches

The distribution level Station LAN switch typically does not connect directly to station equipment requiring copper ethernet ports, but does so through a second IT switch, the access Station LAN switch. However, there is at least one copper ethernet connection, that connects directly to the distribution LAN Switch:

6. Digital Video Recorder (DVR), via dual 10 Gbps copper ethernet connections

H. IT Access LAN

The Contractor must provide at each new EBRC/Capitol Expressway corridor station an IT 1 Gbps access level Local Area Network, connecting directly to station communications devices with 1 Gbps copper ports. The access level LAN switch connects via dual fiber optic 1 Gbps uplinks to the distribution level Station LAN switch. Access local IT 1 Gbps LAN connections include:

1. CCTV Cameras (1 Gbps)
2. Rack Power Distribution Unit (PDU)

I. IT Edge LAN

The Contractor must provide at each new EBRC/Capitol Expressway corridor station multiple 1 Gbps edge level Local Area Networks, connecting directly to station communications devices with 1 Gbps copper ports. The edge level LAN switch connects via dual fiber optic 1 Gbps uplinks to the distribution level Station LAN switch. Edge SCADA LAN switches include but are not limited to:

1. IT Intrusion Detection System Cabinet (IDS) IP edge Switches: To CCTV cameras
2. Elevator IT IP edge Switches: To Elevator CCTV (one fiber uplink, one coax/ethernet uplink)
3. TPSS IT Enclosure IP edge Switches: To CCTV cameras at the TPSS
4. Station IDF IT IP Switches: To CCTV cameras
5. Passenger Information Monitors (PIM) IDF IT IP Switches
6. Fare Collection TVM IDF IT IP Switches: To TVMs, AVMs, and CIDs

2.02 STATION SCADA LAN AND STATION IT LAN EQUIPMENT

A. General LAN Requirements: All equipment furnished, assembled, fabricated or installed under this item must be compliant with the following:

1. LAN equipment must be commercially available through multiple sellers or distributors and must be commercially available off-the-shelf equipment.
2. All necessary LAN interconnecting hardware, cable management hardware, cables and any media converter equipment must be included. Contractor must coordinate LAN cable lengths, copper cable length limitations, and equipment locations with the VTA and must be responsible for the total connectivity and interoperability of the equipment utilizing the LAN. All LAN drop cables must be outlet-terminated and have sufficient slack to allow for work area outlet positioning, and three reterminations of copper or fiber cable in the future.
3. LANs must utilize TCP/IP as the transport and network layer services.
4. Each device connected to the LAN must be manageable by a single SNMP based manager application running on the System Manager’s Workstation.
5. The LAN cable plant must be designed in accordance with TIA/EIA-568-A and must consist of LAN electronics, connecting hardware, patch cords, horizontal cabling, work area outlets, and work area cables (cords). All LAN electronics including switches and associated transceivers and the cross connect fiber optic and digital patch panels and associated patch cords must be housed in the Communications Cabinets or racks, or on the Communications or IT room walls if approved by VTA.

6. All LAN components must be in compliance with the referenced and applicable standards, including but not limited to switches, routers, network interface cards, transceivers, media converters, and the network cable plant.

7. Environmental Requirements as specified:

   a. Ambient environmental operating conditions as specified.

   b. All specified requirements must be met during uncontrolled environmental operation characterized by a temperature range of –20°C to +60°C and a humidity range of 5 percent to 95 percent (non-condensing), plus a solar radiation temperate rise of 50 degrees F.

   c. Electromagnetic Compatibility specified in Federal Communications Commission Rules, Part 15, Subpart B, Class A.

8. Safety Requirements:

   a. Underwriter's Laboratory (UL) listing for restricted access installations in business and customer premises applications. This listing is required by NFPA 70 for customer premises installations.

   b. Fire resistance requirements specified by UL 1459.

   c. Quality Requirements: The Multiplexer vendor must provide evidence of a strong commitment to quality manufacturing including ISO9000 certification of the manufacturing facilities.

9. All wires to and from the wire connectors must be color-coded and/or appropriately marked. All necessary connectors, cable harnesses and accessories must be provided with the equipment.

10. Reliability Requirements:

    a. After an AC power outage, the equipment must automatically reboot and be operational within one minute of the restoration of normal power without manual intervention.

    b. All equipment must be powered from the station Uninterruptible Power Supply (UPS), or remote TPSS or IDS UPS.

    c. Ethernet switches must automatically disable "jabbering" ports and then re-enable the port when "jabbering" has stopped.

11. Manageability:

    a. SNMP Management Software (module) as specified must be provided to manage LAN/WAN components.

    b. The SNMP management module must include the network management protocol defined as follows:

       1) RFC 1157 SNMP RFCs 1213, 1493 and 1643 MIB-I and MIB-II

       2) RFC 1212 Concise MIB Definitions

       3) RFC 1155 SMI

    c. The SNMP management module must include an SNMP agent on the network management module.

d. The SNMP agent must include RFC 1158 Management Information Base (MIB) objects for "Get Request" and "Set Request."

e. Operations of all applicable MIBs. The SNMP agent must support "set" of all read-write MIB II objects.

f. The SNMP agent must report correct trap messages for "link down" and "cold restart."

g. The SNMP agent must provide notification of an unauthorized access attempt.

h. The SNMP agent must maintain current values of each variable of the MIB, and report values accurately and consistently.

i. The SNMP agent must include specific MIB variables for the LAN switch's environmental state such as temperature and voltage.

j. The LAN switch must include flexible access to the management modules for configuration setup and changes. It must include facility for configuration changes from a local or remote workstation.

k. The equipment must include remote configuration changes through SNMP that include enable, disable and reset of an individual port.

l. The LAN switch's management module must include reporting of the switch's configuration to both a local workstation and to the System Manager's Workstation.

m. Configuration changes must not cause the LAN switch to reboot and must be reported through the SNMP agent.

n. The LAN switch must have power-up and stand alone diagnostics on all hardware components.

o. The SNMP management modules must monitor Ethernet traffic on all ports.

p. The SNMP management module's SNMP agent must count and report network traffic of transmitted, received, broadcast, and packets-in-error correctly for each port.

q. The LAN switch must support the RMON standard. The RMON function must monitor and report network statistics on all ports.

r. The SNMP agent must have user defined SNMP Community names. The System Manager must be able to change the default community name.

12. Performance Requirements:

a. The LAN switch must operate with a fully loaded configuration without performance degradation.

b. The power supply must have sufficient capacity to support a fully loaded LAN switch.

c. The SNMP management module must operate and fully handle traffic on a fully loaded network. It must be able to respond to an SNMP poll or initiate trap messages within one second.

13. Software Requirements:

a. The LAN switch must support centralized configuration management software such that its configuration can be downloaded from the System Manager's Workstation.

B. Hardware Requirements:

1. The equipment must use 115 V (ac), 60 Hz power.
2. All equipment must be rack mountable on ANSI/EIA-310D 483 mm (19 in.) EIA standard rack.
3. All equipment must comply with UL 478 safety requirements.
4. All equipment must meet FCC part 15, subparagraph J, Class A limits for electromagnetic radiation.
5. The LAN switch must have a minimum of 24 1000BASE-T/TX ports within the switch enclosure.
6. The equipment must operate under the following conditions:
   a. Temperature: 0^{o} C to 50^{o} C (32^{o} F to 122^{o} F).
7. Relative Humidity: 5 percent to 95 percent Non-Condensing.

2.03 SCADA DISTRIBUTION STATION LAN SWITCHES

A. SCADA Distribution Station LAN Switches must include:

1. Twenty-four or more 1 Gigabit Ethernet SFP SM fiber optic ports, or 50 percent spare capacity (of total switch ports) whichever is greater.
2. Twenty-four or more 1 Gigabit Ethernet SFP MM fiber optic ports, or 50 percent spare capacity (of total switch ports) whichever is greater.
3. Eight SM fiber optic 10 Gigabit 10GBASE-ER Ethernet SFP uplinks, or 50 percent spare capacity (of total switch ports) whichever is greater. The SFP must be 10GBASE-LR, 10GBASE-ER, or 10GBASE-ZR depending on uplink distances.
4. Suitable for 19” rack mounting.
5. Dual redundant, modular power supplies and fans, 120 Vac input
6. Four fan trays with online insertion and removal.
7. Stackable for future increase to up to two stacked switches
8. IPv4 and IPv6 routing, Multicast routing, advanced quality of service (QoS), and security features in hardware
9. Properly interact with Cisco Rapid Spanning Tree Protocol, per VLAN.
10. Environmental operating conditions:
    a. Temperature: 32 to 113 degrees F
    b. Humidity: 5 to 90 percent relative humidity (noncondensing)
11. Mean Time Between Failure: Greater than 250,000 hours
12. Include remote configuration and diagnostics software and functionality.
13. The SCADA Distribution Switches must be comprised of the appropriate model Cisco Catalyst C9500-48Y4C switch with the IP Services feature set, Network modules, appropriate SFPs, and two Cisco PWR-C9K-PWR-650WAC-R redundant power supplies, and Four C9K-T1-FANTRAY fan trays or approved equal.

2.04 INFORMATION TECHNOLOGY (IT) DISTRIBUTION STATION LAN SWITCHES

A. IT Distribution Station LAN Switches must include:

1. Twenty-four or more 1 Gigabit Ethernet SFP SM fiber optic ports, or 50 percent spare capacity (of total switch ports) whichever is greater.

2. Twenty-four or more 1 Gigabit Ethernet SFP MM fiber optic ports, or 50 percent spare capacity (of total switch ports) whichever is greater.

3. Eight SM fiber optic 1/10 Gigabit Ethernet SFP uplinks, or 50 percent spare capacity (of total switch ports) whichever is greater. The SFP must be 10GBASE-LR, 10GBASE-ER, or 10GBASE-ZR depending on uplink distances.

4. Two 1 Gigabit uplinks may be required to interface with the existing IT networks and must be provided.

5. Suitable for 19” rack mounting.

6. Dual redundant, modular power supplies and fans, 120 Vac input

7. Four fan trays with online insertion and removal.

8. Stackable for future increase to up to two stacked switches

9. IPv4 and IPv6 routing, Multicast routing, advanced quality of service (QoS), and security features in hardware

10. Properly interact with Cisco Rapid Spanning Tree Protocol, per VLAN.

11. Environmental operating conditions:

    a. Temperature: 32 to 113 degrees F

    b. Humidity: 5 to 90 percent relative humidity (noncondensing)

12. Mean Time Between Failure: Greater than 250,000 hours

13. Include remote configuration and diagnostics software and functionality.

14. The IT Distribution Switches must be comprised of the appropriate model Cisco Catalyst C9500-48Y4C switch with the IP Services feature set, Network modules, appropriate SFPs, and two Cisco PWR-C9K-PWR-650WAC-R redundant power supplies, and Four C9K-T1-FANTRAY fan trays or approved equal.

2.05 SCADA ACCESS STATION LAN SWITCHES

A. SCADA Access Station LAN Switches must include:

1. Twenty-four 1000BASE-T/TX RJ45 POE+ Ethernet ports or 50 percent spare capacity (of total switch ports) whichever is greater.

2. Four SM fiber optic 10 Gigabit 10GBase-X Ethernet SFP/SFP+ uplinks or 50 percent spare capacity (of total switch ports) whichever is greater.

3. Suitable for 19” rack mounting.

4. Dual redundant, modular power supplies and fans, 120 Vac input

5. Two fan trays with online insertion and removal.

6. Stackable for future increase to up to eight stacked switches

7. IPv4 and IPv6 routing, Multicast routing, advanced quality of service (QoS), and security features in hardware

8. Properly interact with Cisco Rapid Spanning Tree Protocol, per VLAN.

9. Environmental operating conditions:

    a. Temperature: 32 to 113 degrees F

    b. Humidity: 5 to 90 percent relative humidity (noncondensing)

10. Mean Time Between Failure: Greater than 250,000 hours

11. Include remote configuration and diagnostics software and functionality.

12. The SCADA Access Switches must be comprised of the appropriate model Cisco Catalyst C9200L-24P-4X switch with the IP Services feature set, Network modules, appropriate SFPs and accessories, and two Cisco PWR-C5-600WAC redundant power supplies, or approved equal.

2.06 INFORMATION TECHNOLOGY (IT) ACCESS STATION LAN SWITCHES

A. IT Access Station LAN Switches must include:

1. Twenty-four 1000BASE-T/TX RJ45 POE+ Ethernet ports or 50 percent spare capacity (of total switch ports) whichever is greater.

2. Four SM fiber optic 10 Gigabit 10GBase-X Ethernet SFP/SFP+ uplinks or 50 percent spare capacity (of total switch ports) whichever is greater.

3. Suitable for 19" rack mounting.

4. Dual redundant, modular power supplies and fans, 120 Vac input

5. Two fan trays with online insertion and removal.

6. Stackable for future increase to up to eight stacked switches

7. IPv4 and IPv6 routing, Multicast routing, advanced quality of service (QoS), and security features in hardware

8. Properly interact with Cisco Rapid Spanning Tree Protocol, per VLAN.

9. Environmental operating conditions:

    a. Temperature: 32 to 113 degrees F

    b. Humidity: 5 to 90 percent relative humidity (noncondensing)

10. Mean Time Between Failure: Greater than 250,000 hours

11. Include remote configuration and diagnostics software and functionality.

12. The IT Access Switches must be comprised of the appropriate model Cisco Catalyst C9200L-24P-4X switch with the IP Services feature set, Network modules, appropriate SFPs and accessories, and two Cisco PWR-C5-600WAC redundant power supplies, or approved equal.

2.07 SCADA EDGE STATION LAN SWITCH & ENCLOSURE

A. SCADA Edge Station LAN Switches must include:

1. 8 or more 1000BASE-T/TX RJ45 POE+ Ethernet ports or 20 percent spare capacity (of total switch ports, round up decimal) whichever is greater.
2. Provide one or more of this ethernet switch to meet the required port capacity, housed within the same enclosure, per location, on a 35mm DIN rail mount.
3. Per switch, provide two redundant fiber optic 1 Gigabit 1000BASE-SX (MM) or 1000BASE-LX (SM) Ethernet uplink (depending on fiber cable type and distance) interfaces, including SFPs as applicable with SC or LC type pluggable optic fiber connectors, LC preferred.
4. Fully managed, layer 2 (switching), layer 3 (routing between VLANs).
5. Modular power supply, low voltage 12 to 72 VDC (nominal 48 VDC for non POE, 54 VDC for POE+).
6. IEEE 802.3af POE and 802.3at POE+ compliant for all RJ-45 Ethernet ports, as required for connected devices.
7. Properly interact with 802.1w Rapid Spanning Tree Protocol, per VLAN.
8. Blower as required, fanless construction preferred.
9. Switches are within an enclosure and subject to solar radiation extremes include a minimum of thermal heating from equipment heat production plus a 50 degrees F additional solar thermal increase.
10. Switch must be environmentally hardened with extended equipment operating temperature range of -40 degrees F to 167 degrees Fahrenheit, minimum capability, 185 degrees F preferred. Contractor remains responsible for controlling included enclosure within operating limits of the switch provided.
11. Contractor must supply an Environmental and Security Monitoring Unit, DIN rail mounted, along with enclosure door contacts reporting to the ESMU and then to the SCADA system via SNMP, for security monitoring. Contractor must configure the NMS to alarm when the door contact is activated. VTA must provide integration of SNMP alarms from the NMS to interface with the SCADA CCS system at the OCC.
12. Provide a weatherproof stainless steel NEMA 3R or 4X rated enclosure (4X preferred) for the switch and related equipment, and must be painted to match the station color scheme when placed in public areas, with a color to be selected by VTA.
13. The switch and related equipment, must be placed in the weatherproof enclosure, and must be mounted on a light pole, surveillance pole or station shelter structure provided by others; the switch must be suitable for this environmental extreme, in direct sunlight and ambient conditions specified.
14. The enclosure must be sized to accommodate one or more Edge Ethernet Switches as required.
15. Provide an aesthetically acceptable solution as approved by VTA, for enclosures mounted in public areas.
16. Include remote configuration and diagnostics software and functionality.

17. Must be Simple Network Management Protocol (SNMP) capable.

18. The IT Edge Switches must be comprised of the appropriate model Siemens Ruggedcom RS900G (non POE), RS900GP (POE, POE+); Cisco Catalyst IE-3200-8T2S-E (non POE), IE-3200-8P2S-E (POE, POE+), with Cisco Catalyst IEM-3300-8T or 8p; or Cisco Catalyst IEM-3300-16T or 16P expansion modules as required; with IP services feature set, hardened SFP network modules as required, external power supply sized for the required POE/POE+ demand, as required and all appropriate accessories or approved equal.

2.08 INFORMATION TECHNOLGOY (IT) EDGE STATION LAN SWITCH & ENCLOSURE

A. IT Edge Station LAN Switches must include:

1. 8 or more 1000BASE-T/TX RJ45 POE+ Ethernet ports or 20 percent spare capacity (of total switch ports, round up decimal) whichever is greater.

2. Provide one or more of this ethernet switch to meet the required port capacity, housed within the same enclosure, per location, on a 35mm DIN rail mount.

3. Per switch, provide two redundant fiber optic 1 Gigabit 1000BASE-SX (MM) or 1000BASE-LX (SM) Ethernet uplink (depending on fiber cable type and distance) interfaces, including SFPs as applicable with SC or LC type pluggable optic fiber connectors, LC preferred.

4. Fully managed, layer 2 (switching), layer 3 (routing between VLANs)

5. Modular power supply, low voltage 12 to 72 VDC (nominal 48 VDC for non POE, 54 VDC for POE+).

6. IEEE 802.3af POE and 802.3at POE+ compliant for all RJ-45 Ethernet ports, as required for connected devices.

7. Properly interact with 802.1w Rapid Spanning Tree Protocol, per VLAN.

8. Blower as required, fanless construction preferred.

9. Switches are within an enclosure and subject to solar radiation extremes include a minimum of thermal heating from equipment heat production plus a 50 degrees F additional solar thermal increase.

10. Switch must be environmentally hardened with extended equipment operating temperature range of -40 degrees F to 167 degrees Fahrenheit, minimum capability, 185 degrees F preferred. Contractor remains responsible for controlling included enclosure within operating limits of the switch provided.

11. Contractor must supply an Environmental and Security Monitoring Unit, DIN rail mounted, along with enclosure door contacts reporting to the ESMU and then to the SCADA system via SNMP, for security monitoring. Contractor must configure the NMS to alarm when the door contact is activated. VTA must provide integration of SNMP alarms from the NMS interface with the SCADA CCS system at the OCC.

12. Provide a weatherproof stainless steel NEMA 3R or 4X rated enclosure (4X preferred) for the switch and related equipment, and must be painted to match the station color scheme when placed in public areas, with a color to be selected by VTA.

13. The switch and related equipment, must be placed in the weatherproof enclosure, and must be mounted on a light pole, surveillance pole or station shelter structure provided by others; the switch must be suitable for this environmental extreme, in direct sunlight and ambient conditions specified.

14. The enclosure must be sized to accommodate one or more Edge Ethernet Switches as required.

15. Provide an aesthetically acceptable solution as approved by VTA, for enclosures mounted in public areas.

16. Include remote configuration and diagnostics software and functionality.

17. Must be Simple Network Management Protocol (SNMP) capable.

18. The IT Edge Switches must be comprised of the appropriate model Siemens Ruggedcom RS900G (non POE), RS900GP (POE, POE+); Cisco Catalyst IE-3200-8T2S-E (non POE), IE-3200-8P2S-E (POE, POE+), with Cisco Catalyst IEM-3300-8T or 8p; or Cisco Catalyst IEM-3300-16T or 16P expansion modules as required; with TCP/IP protocol suite, IP services feature set, hardened SFP network modules as required, external power supply sized for the required POE/POE+ demand, as required and all appropriate accessories or approved equal.

2.09 COMMUNICATIONS HUB (DEVICE/TERMINAL SERVERS):

A. These devices are provided by the signal system, refer to signal specifications.

2.10 LAN MEDIA CONVERTERS:

A. LAN Media converters must be very limited, and not be utilized except for PIM display signs, and at other locations for unique conditions unless approved by VTA.

B. LAN Media converters must convert the 1000BASE-T/TX ports of the Ethernet switch to 10BASE-FL or 100BASE-SX or 1000BASE-LX as applicable to the attached device media transmission.

C. Media converters must be installed in rack mounted card cages.

D. The Converters must comply with the following requirements:

1. 10BASE-T to 10 BASE-FL Converter:

a. Interfaces: 10BASE-T (RJ-45), 10BASE-FL (SC or LC).

b. Protocol Compatibility: IEEE 802.3 10BASE-T and 10BASE-FL standards.

c. Operating Distance: 100 m for 10BASE-T, 2 km for 10BASE-FL when connected to a switch.

d. Data Flow: Half or Full Duplex Support.

e. LEDs: Power, Link, Transmit, Receive.

f. Fiber Requirements: Multimode fiber cabling with SC or LC connectors or Single mode fiber cabling with SC or LC connector.

2. 1000BASE-T/TX to 100BASE-SX Converter:

a. Interfaces: 1000BASE-T/TX (RJ-45), 100BASE-SX (SC or LC).

b. Protocol Compatibility: IEEE 802.3ab 1000BASE-T/TX and 1000BASE-SX standards.

c. Operating Distance: 100 m for 1000BASE-T/TX, 300 m for 100BASE-SX when connected to a switch.

d. Data Flow: Half or Full Duplex Support.

e. LEDs: Power, Link, Transmit, Receive.

f. Fiber Requirements: Multimode fiber cabling with SC or LC connectors or Single mode fiber cabling with SC or LC connector.

3. 1000BASE-T/TX to 1000BASE-SX or LX Converter:

a. Interfaces: 1000BASE-TX (RJ-45), 1000BASE-SX or LX (SC or LC).

b. Protocol Compatibility: IEEE 802.3ab 1000BASE-TX and IEEE 802.3z 1000BASE-SX standards.

c. Operating Distance: 100 m for 1000BASE-T/TX, 220m to 550m for 1000BASE-SX and 5 km for 1000BASE-LX when connected to a switch.

d. Data Flow: Half or Full Duplex Support.

e. LEDs: Power, Link, Transmit, Receive.

f. Fiber Requirements: Multimode fiber cabling with SC or LC connectors or Single mode fiber cabling with SC or LC connector.

2.11 NETWORK MANAGEMENT SYSTEM (NMS) SYSTEM SOFTWARE

A. Integrate all ethernet switches provided under this contract, with “What’s Up Gold”, the existing VTA Network Management Platform. Provide additional licenses for equipment furnished under this contract.

B. In addition to licenses for the existing VTA, NMS, provide, install, configure and integrate the current versions of the SolarWinds Network Management System (NMS), including application and other software and any required licenses for all computer and networking equipment provided under this Contract, for the following products:

1. Solarwinds Network Automation Manager.

2. The Solarwinds Network Automation Manager software must be provided, installed, and configured by the Contractor on existing VTA Windows servers. Current versions of the Microsoft Windows operating system will be installed by VTA on each server.

2.12 NETWORK SYNCHRONIZATION

A. All switches and other network elements must utilize the Network Time Protocol (NTP) source as designated by the VTA Network Manager at the time of installation.

2.13 EQUIPMENT RELIABILITY

A. All LAN switches/hubs/routers must have an MTBF of at least 100 000 hours.

B. All serial data bridges must have an MTBF of at least 100 000 hours.

PART 3 - EXECUTION

3.01 FACTORY TESTING

A. A 72-hour burn-in must be performed for all LAN equipment.

B. Subsequent to burn-in:

1. Diagnostic testing must be performed for all equipment and all communications ports.

2. Functional testing must be performed for all equipment.

3. Validation of equipment settings must be performed for all equipment.

3.02 INSTALLATION

A. Topology:

1. The physical and electrical topology of the LAN must be consistent with the TIA/EIA-568-A definition for a star topology, from distribution to access and edge switches.

2. Each node on the star must be assigned both a physical (Ethernet) and a logical (e.g., IP) address.

3. The Contractor must provide segmentation of LAN traffic by station and by subsystem in manner similar to the similar installations performed under the previous VTA S945, C670 and C640 Contracts. The Contractor must submit a plan for subnet and masking assignments for all devices attached to the LAN. The Contractor must work with the VTA regarding the existing and desirable network address assignment blocks and other network settings.

4. Prior to implementation of the network configuration parameters for the new and existing network equipment, the Contractor must submit these configuration values for approval by the VTA.

B. General:

1. Physical Audit and Inventory: The Contractor must perform a physical audit and inventory of equipment to be delivered prior to delivery to VTA. Inventory data must be provided to VTA prior to shipment. Upon delivery, the Contractor, with the VTA, must repeat the physical audit and confirm the inventory data, and check for any shipping damage.

2. The Contractor must provide serial data communications cable between the Device Servers and Signal System field devices such as TWCs and Event Recorders.

3. Cable and patch field connectors must be clearly labeled.

4. Cable routing must be arranged neatly and securely.

5. Tagging:

   a. Wire and cable must be permanently tagged by a white sleeve tag with permanent black 3 mm (1/8 in.) minimum height lettering. Network configuration records must be created and maintained. Tag labeling and network records must be in accordance with TIA/EIA-606.

   b. All jacks must be identified using permanently mounted white tags with permanent black 3 mm (1/8 in.) minimum height lettering.

C. LAN Hardware:

1. Ducts carrying LAN cabling must be installed in accordance with TIA/EIA-569 and properly grounded according to TIA/EIA-607 and MIL-HDBK-419A standards.

2. LAN copper cable must be routed away from all sources of interference, including power lines, motors, radio interference, fluorescent lighting, and heavy machinery.

3. The LAN cable must be installed in inner duct and routed via protected risers and overhead raceway. The LAN equipment must be installed to provide sufficient immunity from all electromagnetic disturbances at the VTA Rail Operations Facility and Communication Nodes.

4. Network connections, except those for devices in the same cabinet as the LAN switch must be made to devices using twelve-fiber optical cable as specified herein. Connections internal to the cabinet servicing the LAN switch must be category 6 unshielded twisted pair cable. Station LAN fiber optic cable must be installed as shown on the Contract Drawings.

5. All fibers within optical cables servicing network connections from devices at stations must be terminated at a fiber distribution panel housed in the same cabinet as the (Station) LAN switches.

6. Work area outlets (WAO) must be provided for PIMs, IDS Cabinets, Elevator Rooms, PACs and other devices as shown on the Contract Drawings. A six position outlet for TVMs must be provided. The contractor must terminate all fibers within the serving cable to SC connectors at these outlets. The connectors must be attached to the SC sleeves housed within the outlets. Dust plugs must be installed in ports not in use.

D. Station and Wayside Network Equipment Installation:

1. Industrial hardened switches and power supplies must be 35 mm DIN rail mounted.

2. The Station and Wayside SCADA and IT Equipment, Power Supplies, and Switches must be powered by the Uninterruptible Power Supplies (UPS) at the stations, TPSS, or Signal Case. The IDS Cabinet LAN Switch must be powered by the IDS Cabinet UPS.

3. IEEE RJ-45 CAT-6 rated Ethernet jumper cables must be used to connect the switch ports to the indicated RJ-45 distribution panel or the indicated RJ-45 copper to fiber media converters.

4. The Contractor must install the station and wayside network equipment as shown in the Contract Drawings. All cables must be secured to the cabinets or racks and if existing cable installations prevent the adequate securing of the new equipment or cable, the existing cables must be dismounted and re-secured.

5. LAN switches, terminal servers and peripherals must be rack-mounted within communications rooms at the stations. (freestanding units are not acceptable). Ports must be clearly labeled.

6. All software settings for the SCADA and IT Ethernet equipment must be configured/programmed as approved by VTA. The Contractor must report to VTA for direction if any unexpected deviations from the intended installation settings are encountered in the field.

7. All outside plant (OSP) cable jackets and central strength members must be secured to the fiber distribution panel enclosure for strain relief.

3.03 LAN EQUIPMENT CUTOVER

A. The Contractor must complete all field (local) testing prior to the cutover to the existing VTA equipment.

B. Each Station’s equipment must be tested independently prior to connection to the SCADA Ring 2 and IT Loop E Networks.

C. Installation of the SCADA and IT LAN equipment and software must be coordinated with VTA to allow for ongoing operation of the existing control system, until field testing of the new station equipment within the new LRT System territory is complete.

3.04 ON-SITE SCADA AND IT LAN HARDWARE INSPECTION

A. The following inspection checks must be performed on all deliverable hardware, as a minimum:

1. Equipment labeling.
2. LAN Switch port labeling.
3. LAN and data communications cable labeling.
4. Server and terminal server port labeling.
5. Power supply mounting.
6. Power cable routing and data cable routing.
7. Unobstructed airflow paths for fans and blowers.

3.05 SCADA AND IT LAN EQUIPMENT TESTS

A. The Contractor must perform all manufacturers recommended equipment and cable testing. All available equipment built-in unit and communications paired tests must be performed. All equipment configuration, management and diagnostic functions must be exercised and demonstrated as operational. Diagnostic hardware testing must be performed for all equipment upon installation at VTA.

B. Operating system software and LAN software testing must be performed for all SCADA and IT Ethernet and computer equipment.

C. The Contractor must confirm that all spare parts are in complete working condition.

D. Configuration settings for all equipment must be verified after power-on.

E. Interface testing, including testing of each data communications path and each LAN communications path to the Station SCADA and IT LANs must be performed.

F. Station LAN Cable Plant: The Contractor must perform the following tests for each LAN node connection:

1. OTDR and Optical Attenuation tests for all fibers including spares from the LAN FDP to the equipment work area outlet, in both directions.
2. Bit Error Rate and Bandwidth test from the LAN FDP to the equipment work area outlet. The test must be performed using IEEE 802.3 compliant transmission of the test data.
3. Bit Error Rate test and Bandwidth test from the VTA Rail Operations Facility or VTA Adminstrative Facility end unit to the station unit. The connection must be tested from both directions.
4. Network communications from the LAN including ping and SNMP agent functions. The SNMP agent must be tested for all available status, control, and management functions including manufacturer's MIB variables.
5. All applicable remote management and configuration functions must be tested from the SCADA and IT LANs and from the local craft interface port.

G. Station, VTA Administrative Facility and VTA Rail Operations Facility (VROF) Contractor installed equipment: The Contractor must perform the following additional tests:

1. The Contractor must perform all manufacturer recommended tests on all new equipment to verify that the equipment is fully functional at the time of installation.

2. The Contractor must test all ports of all new network equipment to verify that all ports are fully functional.

3. Ring 2 and Loop E equipment failover testing must be performed to show proper configuration and connections for the installed hardware.

4. Verify proper routing of network data to and from the CCS LAN to the appropriate Station SCADA or IT Ethernet LAN and Node. The Contractor must verify that the sub-net design allows test data to appear only at the intended destinations.

5. Measure maximum throughput from the SCADA and IT Ethernet LAN to each corresponding station SCADA or IT Ethernet LAN switch under normal operating conditions.

6. Verify that the operational and spare ports on all of the switches are in working order.

7. Verify that only the ports for each SCADA and IT switch are configured to the correct VLAN, and that the other ports are not. Verify that other ports are mapped to the correct VLANs as approved by VTA.

8. Verify that, with the new stations' SCADA and IT Ethernet equipment, the Rapid Spanning Tree configuration converges at the Field Aggregation switches (IT) or at the VROF node 2 (SCADA) when a break in each loop occurs and record the time the loop convergence takes.

    a. Test by powering off a station switch in each loop.

    b. Test by unplugging the fiber to an SFP in each loop.

    c. Test by unplugging the loop fiber to an SFP at the field aggregation switch.

    d. Test by unplugging the fiber at an SFP between the field aggregation switch and each core aggregation switch.

    e. Insure that the VLANs to each station are still operational after each break.

    f. Insure that the Spanning Tree configuration re-converges and that the VLANs to each station are still operational after each break is restored.

9. Verify Rapid Spanning Tree convergence for each dual uplink hardened remote EDGE switch, by disconnecting both uplinks one link at time, and record the time the link convergence takes.

10. Verify that the operational and spare ports on all of the station and aggregation switches are in working order.

11. Verify that the CCS Firewall is configured to allow only authorized data traffic and access to the network devices by using the methods outlined in the National Institute of Standards and Technology (NIST) publication 800-42 "Guideline on Network Security Testing" to include the following:

    a. Network scanning.

    b. Vulnerability scanning.

12. Integration Testing: Conduct end-to-end testing for each communication device interface initiating an indication at the field device and observing the proper response at the head-end equipment at the VTA Administrative Facility or VROF Facility. Conduct the reverse end-to-end testing by initiation a control at the head-end equipment and observing the proper response at every field device.

H. All methods and tools used to perform tests must be documented in hardcopy and supplied to VTA in electronic format. All results of the tests must be documented and supplied to VTA in hardcopy and electronic format.

3.06 REMOVAL OF EXISTING EQUIPMENT

A. The Contractor must remove, pack and store any equipment and/or material that is supplanted by new equipment and/or material, at a location identified by VTA.

3.07 FIELD QUALITY CONTROL

A. Quality: The quality of the Communications System installation must be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications and workmanship standards and practices.

END OF SECTION

SECTION 27 26 00

COMMUNICATIONS PROGRAMMING AND SYSTEMS INTEGRATION

PART 1 - GENERAL

1.01 SUMMARY

A. The section includes functional requirements for modifications to the Central Control System CCS by the Contractor, to include installation of a new Station Control Unit as part of the Public Address system.

B. All other modifications to the CCS at VROF must be completed by VTA. The Contractor must perform all testing at EBRC stations, TPSS, and guideway to support all system integration testing by VTA at the OCC to demonstrate the required CCS functionality to include all field devices installed by the Contractor.

C. All modifications to the Passenger Information Monitor system at VROF or VTA Administrative Facility will be completed by VTA. The Contractor must perform all testing at EBRC stations, to support all system integration testing by VTA at VTA Administrative Facility to demonstrate the required PIM system functionality to include all field devices installed by the Contractor.

D. This Section includes functional and performance requirements for modifications of the Central Control System (CCS). CCS will be used to support supervision of VTA LRT operation from the OCC. The Central Communication System (CCS) software must be upgraded to provide for supervision of the light rail transit (LRT) system equipment and systems for the three new stations from the OCC at VROF. The CCS must provide for the new stations and substations all of the current features and functionality of the existing stations and substations. Once upgraded, the CCS will monitor and, in response to user commands, control remote equipment and systems on the entire light rail transit system, including the existing lines as well as the extension, as one fully integrated system

1.02 RELATED SECTIONS

A. Section 27 05 00, Common Work Results for Communications

B. Section 27 05 28, Pathways for Communications Systems

C. Section 27 11 16, Communications Cabinets, Racks, Frames and Enclosures

D. Section 27 11 19, Communications Terminal Blocks and Patch Panels

E. Section 27 13 00, Communications Network Cabling

F. Section 27 15 00, Communications Low-Voltage Conductors and Cables

G. Section 27 21 00, Communications Network Equipment

H. Section 27 30 00, Telephone System

I. Section 27 42 19, Public Address System

J. Section 27 42 20, Passenger Information Monitor System

K. Section 28 20 00, Video Surveillance (CCTV)

L. Section 28 31 00, Intrusion Detection System (IDS)

M. Section 28 40 00, SCADA Monitoring and Control System

N. Section 34 54 00, Automated Fare Collection System

1.03 REFERENCED STANDARDS

A. The latest versions of the following standards and references apply to the work included in this Section:

1. IEEE STD 730, Standard for Software Quality Assurance Plans.

2. IEEE STD 730.1, Guide for Software Quality Assurance Plans.

1.04 QUALITY ASSURANCE

A. Inspection: VTA reserves the right to make inspection and tests as necessary to determine if the Integrated CCS installation and Contractor provided communications system meets the requirements of these technical specifications. VTA reserves the right to reject any part or all of the installation that is defective in any respect. VTA reserves the right to request additional tests to provide further satisfaction that the Overall System has been installed in accordance with the requirements of these technical specifications at no additional cost to the Contract.

1.05 SUBMITTALS

A. The following submittals, must be provided by the Contractor during conduct of the project, and are subject to review and approval of the VTA:

B. Integration Test Plans and Procedures to demonstrate functionality of Contractor supplied hardware and software.

C. Integration Test Reports and Test Data Sheets filled out and witnessed by VTA during tests.

1.06 MEASUREMENT AND PAYMENT

A. Measurement: Communications Low-Voltage Conductors and Cables must be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Communications Low-Voltage Conductors and Cables must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in this Section complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

A. Summary: All products are specified in other EBRC specifications, including the Public Address Station Control Unit.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Installation of CCS hardware and/or software must not take place until the CCS factory testing is successfully completed and accepted for both CCS software and hardware, and all defects found through the end of the factory testing have been fixed and successfully re-tested.

3.02 TESTING OVERVIEW

A. VTA has an existing Communications System serving the Guadalupe, Vasona, Tasman West, Tasman East and Capitol Corridors. This system includes an existing supervisory control system (also referred to as the existing SCADA system), which supports these lines, which monitors and controls:

a. Signal System.

b. Traction Electrification System.

c. Station Facilities.

d. Miscellaneous Wayside Facilities and Equipment.

e. Ticket Vending Machines and CID.

f. Communications equipment.

g. The VTA Rail Operations Facility (VROF)

B. CCS provides for supervision of LRT System equipment and systems from the OCC. CCS must monitor and, in response to user commands, control remote equipment and systems on the entire Light Rail Transit system, including existing lines as well as the new extension, as one fully integrated system.

C. The existing supervisory control system must be updated with the two new stations and the associated facilities.

D. All functions, software elements, database elements, and console display types to be provided as a part of this upgrade to the CCS are currently in place in the existing supervisory control system. For those displays, the currently in-place display layouts and operation must serve as the starting point. The Contractor must support the update of the existing CCS, PA & PIM System application software and displays with the new station/wayside devices associated with the 2 new passenger stations in a manner previously established under the S945 project, except for the PIM system which is now standalone sytsem. Unless approved by VTA, there must be no loss of existing functionality as a result of the SCADA screens/database/software updates for the current project.

E. VTA must upgrade the Central Communication System (CCS) software to provide for supervision of the light rail transit (LRT) system equipment and systems for the two new stations from the OCC at VROF. The CCS must provide for the new stations and substations all of the current features and functionality of the existing stations and substations. The Contractor must support this VTA work, through Systems Integration of Contractor supplied hardware and software, to make a complete and functioning CCS system.

F. The CCS will be used to support supervision of VTA LRT operation from the OCC. The Central Communication System (CCS) software must be upgraded by VTA to provide for supervision of the light rail transit (LRT) system equipment and systems for the two new stations from the OCC at VROF. The CCS must provide for the new stations and substations to include all the current features and functionality of the existing stations and substations. Once upgraded by VTA, the CCS will monitor and, in response to user commands, control remote equipment and systems on the entire light rail transit system, including the existing lines as well as the extension, as one fully integrated system.

This work includes interfacing to, and integrating with each of the following communications systems described in these items below, to address functionality from remote field devices to operator LRT supervisor and other workstations:

1. Communications Network Cabling.
2. Communications Network Equipment.
3. Telephone System.
4. Public Address System.
5. Passenger Information Monitor System.
6. Video Surveillance (CCTV).
7. Intrusion Detection System (IDS).
8. SCADA Monitoring and Control System.
9. Automated Fare Collection System.
10. Uninterruptible Power Supplies.
11. Equipment and cabinet and or room temperature sensors.
12. Communications Transport System equipment (Core, Distribution, Access and Edge Ethernet Switch Communications Network Equipment and accessories).

G. The following are the Central Control System Functions to be modified to integrate the new Capitol Expressway communication system:

1. Alarm status changes (vital and non-vital systems) and history of the following:

    a. Signal System monitored devices including but not limited to track circuits, traffic and rail signals and rail switches substation breakers and voltage sensors.

    b. Signal System Controls for train route requests.

    c. Ticket Vending Machines and Card Interface devices.

    d. Station Facility Equipment including but not limited to elevators, sump levels, station power and fire and intrusion detection sensors.

    e. Event Recorders.

    f. Missing events (trains appearing past a TWC location or traffic loop detector not previously recorded).

    g. Train to Wayside communication locations.

    h. Wayside equipment including but not limited to Traffic Detector loops, sumps, and emergency telephones.

H. Other CCS features and functionality to be tested in conjunction with Contractor supplied communications systems include:

1. Addition of the station, track, TPSS alarms, monitor data points and control data points will be made to the SCADA database. Addition of all new alarm and new surveillance points to the SCADA Operations and Control Center maps will be completed.

2. Current operating Station Ticket Vending Machines, CIDs, Passenger Information Monitors, Station and LRT System schedules, Adjoining Bus and Rail System schedules (BART, CalTrain, ACE), and Fare Schedules will be integrated into the existing system.

3. Surveillance and passenger safety systems for the new stations will implement:

    a. TVM Alarm system (door open, offline detection, other intrusion).

    b. Cabinet, TPSS, or room intrusion detection.

    c. Public Pay Telephone.

    d. Blue Light or Emergency Trip Stations (emergency phone to OCC) where appropriate.

    e. Elevator status and alarm system.

    f. Fire detection and alarm system.

    g. Station Power detection and vital systems backup power such as emergency lights, signals, and passenger information systems.

4. The Traction Power Substation (TPSS) will include monitored and control features of bulk power input voltage and current measurement, segment power voltage and current use, power breaker control by segment/block, intrusion detection of substation facility, fire sensor, alarm system and the power event recorder and all other current substation data points. All data points are communicated through a remote substation PAC which is connected to the SCADA system though the closest station CTS node.

I. At the VROF Operations and Maintenance facility and the Operations Control Center the Network Management functional system will be expanded to include:

1. Management and reconfiguration of the Hostetter/Capitol ring 2 to integrate the extension of the Ethernet network to support the new nodes and the corresponding station interfaces to the field devices such as PACs, TWCs, VPIs, EVRs, PA, VOIP phones etc..

2. Management and reconfiguration of Loop E to integrate the extension of the Ethernet network to support the new Gigabit Ethernet Nodes and the corresponding station interfaces to the field devices such as TVMs, CIDs, PIMs, CCTV, etc..

3. Addition of station network elements to integrate into the existing network alarm system:

J. Once upgraded, the CCS will monitor and, in response to user commands, control remote equipment and systems on the entire light rail transit system, including the existing lines as well as the extension, as one fully integrated system. All new I/O data points will be added to the existing SCADA database.

3.03 FUNCTIONAL TESTING

A. CCS tests, including failover tests, to show the following must be performed:

1. Correct equipment settings.

2. Correct equipment connectivity.

3. Correct software process configuration.

B. Tests of the data communications and message interface to each existing system and other device must be performed. This testing must include:

1. Data communications testing with each PAC, PIM, all other communications equipment, and the TVM Master (for each TVM).

2. For all PACs and Remote I/O units, monitoring and controlling all indication and control I/O signals through each PAC's I/O block (between the PAC and the field device).

3.04 CCS ON-SITE END TO END TESTS

A. VTA will configure the CCS equipment and software at the VTA OCC to monitor and control the SCADA system based on information provided by the Contractor.

B. The VTA will make personnel available at the VTA CCS as required to support End to End testing by the Contractor.

C. The Contractor is responsible to integrate hardware and software provided by the Contractor, into the overall EBRC LRT Communications System, including VTA provided CCS hardware and software, and all connected field equipment, including equipment provided by others that is controlled and monitored by the CCS.

END OF SECTION

SECTION 27 30 00

TELEPHONE SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes requirements for furnishing, installing and testing station and facility maintenance telephone equipment, to be utilized with the existing two Mitel 3300 MXE VOIP Controllers (One for SCADA Phones, and one for IT Phones) located at the VTA Rail Operations Facility (VROF). CTS interface equipment must be provided for all conventional analog and digital VOIP telephone equipment, telephone work area outlets and instruments supported under this Contract, including VOIP adapters for analog telephones.

B. This Section includes requirements for furnishing analog (PSTN) emergency telephones for elevators, and analog (PSTN) emergency telephone towers for stations. Both telephone types report directly to separate AT&T drops, one per telephone, at each stations.

C. This Section includes requirements for Rail Operations VOIP maintenance telephones, and Information Technology (IT) analog maintenance telephones.

1.02 RELATED SECTIONS

A. Section 27 05 00, Common Work Results for Communications

B. Section 27 05 28, Pathways for Communications Systems

C. Section 27 11 16, Communications Cabinets, Racks, Frames and Enclosures

D. Section 27 11 19, Communications Terminal Blocks and Patch Panels

E. Section 27 13 00, Communications Network Cabling

F. Section 27 15 00, Communications Low-Voltage Conductors and Cables

G. Section 27 21 00, Communications Network Equipment

H. Section 27 26 00, Communications Programming and Integration Services

I. Section 27 42 19, Public Address System

J. Section 27 42 20, Passenger Information Monitor System

K. Section 28 20 00, Video Surveillance (CCTV)

L. Section 28 31 00, Intrusion Detection System (IDS)

M. Section 28 40 00, SCADA Monitoring and Control System

N. Section 34 54 00, Automated Fare Collection System

1.03 REFERENCED STANDARDS

A. The latest versions of the following standards and references apply to the work included in this Section, in addition to those codes and standards common to all communications subsystems specified in section 27 05 00, Common Work Results for Communications. If a conflict must arise between various standards, the California state code amendments must govern, or the most strict/conservative requirement must govern.

B. Federal Communications Commission (FCC):

1. 47 CFR 68 Telecommunication.

C. IEC:

1. 60603-7 Connectors for Frequencies Below 3 MHz for Use with Printed Boards, Part 7: Detail Specification for Connectors, 8-Way, Including Fixed and Free Connectors with Common Mating Features, with Assessed Quality.

D. Underwriters Laboratories Inc. (UL):

1. 1459 Telephone Equipment.

1.04 QUALITY ASSURANCE

A. The Contractor must provide sample telephones to the VTA for approval.

B. All components must be UL listed.

C. The Contractor must coordinate with the Station elevator contractor for details of routing communications cabling to the supplied telephone interface.

1.05 SUBMITTALS

A. Equipment:

1. The Contractor must, as part of the Telephone Subsystem Preliminary Design Review (PDR), submit manufacturer data sheets and one sample instrument for each wired and wireless model for wall, pole and desk type telephone the Contractor proposes to furnish under this Contract.

2. The Contractor must, as part of the PDR, submit manufacturer data sheets for any new interface equipment to be installed in VTA's existing Telephone System Head-End.

3. The Contractor must, as part of the PDR, submit manufacturer data sheets for all remaining new equipment such as VOIP adapters, modems, etc., not specifically mentioned above.

B. Design: As part of the PDR, the Contractor must submit Contract Drawings showing the following information:

1. The location and extension number of each telephone instrument. Extension numbers must be assigned by the Contractor based on a list of available numbers provided by the VTA.

2. The complete transmission path from the PABX/VOIP Gateway to the instrument, including all local intra PABX and VOIP connections, Ethernet switch connection and routing, and cable designations.

3. The complete IP address assignments to the VOIP Gateway, SIP VOIP/Analog Converters and ports, end addresses representing the telephones at the platforms, TPSS, and communications cabinets, bungalows, and electrical rooms. The IP address blocks and LAN/WAN and Firewall equipment security settings must be coordinated with the VTA Communications Manager.

C. Cutover Plan: The Contractor must submit a Cutover Plan submittal package. Contractor must proceed with the equipment cutover only after the approval of Cutover Plan. The VTA must assign cutover dates and times for YMF and each station.

D. Final Design Review: The Contractor must submit a Final Design Review submittal package. The final design review package must include the final design of all components of the system and must incorporate all comments made by the VTA during the Preliminary Design Review and Cutover plan submittals.

E. Installation Drawings. The Contractor must submit installation drawings. Contractor must proceed with the installation only after the approval of installation drawings.

F. Test Reports. Prior to the beginning of the tests, the Contractor must submit test plan and the test procedures for the approval by the VTA. Each test procedure must clearly identify the time, test equipment, location, equipment/function tested and the pass/fail criteria. The Contractor must submit the results of the testing within 15-days after conclusion of the testing. In addition to the test signed by Contractor representatives, all tests must also be witnessed and signed off by the VTA representatives.

G. As-built documentation: Within 6 weeks after the equipment and the functionality of the new system is verified and accepted by VTA, the Contractor must submit the as-built drawings and configuration as-built settings of the implemented system.

1.06 MEASUREMENT AND PAYMENT

A. Measurement: Communications Low-Voltage Conductors and Cables must be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Communications Low-Voltage Conductors and Cables must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in this Section complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 SYSTEM REQUIREMENTS

A. This Section includes requirements for furnishing and installing telephone instruments to be utilized with the existing Mitel SX2000 PABX and Mitel 3300 Telephone VOIP Gateways located at the YMF. CTS interface equipment must be provided for all conventional analog and digital VOIP telephone equipment, telephone outlets and instruments supported under this Contract.

1. Analog MT Telephones – General: The Contractor must furnish, install, wire, and terminate wall-mount or pole-mount, conventional analog single-line or dual-line DTMF compatible telephone instruments, lines, outlets and SIP VOIP/Analog Converters as shown on the Contract drawings. The new analog phone equipment must be terminated at the analog ports of the corresponding SIP VOIP/Analog Converters. The SIP VOIP/Analog Converters must convert digital VOIP Ethernet traffic (transmitted from the VROF Telephone System head-end over the CTS) into the standard 2-wire analog phone signal for distribution at the passenger station telephone equipment. Prior to connecting to the station SIP VOIP/Analog Converters, the wiring for such conventional analog telephone equipment must utilize intermediate protector block equipment for all phone equipment located outside the station communication room/cabinet. In case of station's loss of power, to maintain uninterrupted telephone service at the station, the SIP VOIP/Analog Converters must be powered by the local communication node UPS.

2. SCADA VOIP MT & Operator Break Room Telephones: The Contractor must also furnish, install, wire, and terminate wall-mount or pole-mount, VOIP compatible telephone instruments, lines, outlets and adapters as shown on the Contract drawings. The new VOIP phone equipment must interface at the CTS Communication Nodes. The new VOIP phone equipment must be compatible with the YMF Telephone System head-end and accept the VOIP Ethernet traffic transmitted over the CTS. In case of local loss of power, to maintain uninterrupted telephone service, the VOIP telephone equipment must be powered by a local UPS or a local battery-backed power source.

3. SCADA Analog MT Platform Telephones: The Contractor must furnish, install, wire, and terminate the new conventional analog Wired (Corded) 2-Line Maintenance Telephones (installed in weatherproof, vandal-resistant enclosures) at each station platform as shown on the Contract Drawings. To support the telephone communications with central, these phones must interface with the corresponding station SIP VOIP/Analog Converters. The Contractor must provide for new wiring, protection and termination for connection of the second telephone line to the PA Subsystem.

4. SCADA Analog Wireless MT Communications Room Telephones: Contractor must furnish, install, wire, and terminate the new conventional analog Wireless (Cordless) Maintenance Telephones at each station's communication room/cabinet. To support the telephone communications with central, these phones must interface the corresponding station SIP VOIP/Analog Converters. The Contractor must provide for new wiring, protection and termination for connection of the second telephone line to the PA Subsystem.

5. Contractor must furnish, install, wire, and terminate the new conventional analog 1-line telephone off-platform equipment as shown on the Contract drawings at the following locations:

   a. Signal/Communications Rooms, 2 line (SCADA).
   b. Platform Maintenance Telephones, 2 line (SCADA).
   c. Information Technology Rooms (IT).
   d. Emergency Telephones, on platforms, pedestrian bridge and in elevators (IT).
   e. Communications Node locations or at each passenger station, as indicated on the Contract Drawings and not listed above.
   f. To support the telephone communications with central, these phones must interface the corresponding station SIP VOIP/Analog Converters as required for SCADA telephones, but remain analog directly to AT&T for IT telephones.

6. Contractor must furnish, install, wire, and terminate the new SCADA VOIP digital telephone equipment as shown on the Contract drawings at the following locations:

   a. Electrical rooms.
   b. Mechanical rooms.
   c. Elevator maintenance rooms.
   d. Signal Cases.

e. Traction Power Substations.
f. Operator Facility Break Rooms.
g. Communications Node locations or at each passenger station, as indicated on the Contract Drawings and not listed above.
h. These telephones interface directly to the VROF head end VOIP telephone equipment.

7. Elevator ETELs: The Contractor must wire, terminate and test the conventional analog 1-line elevator intercoms (instrument provided by others), to interface with AT&T POTS lines for ring-down service. The Contractor must provide off-hook status "Elevator Talkplate ON" for each elevator intercom, using normally open electrically isolated dry contact (provided by the Elevator Contract), for connection to the station ELS/IDF Remote I/O unit equipment (provided under this Contract) for SCADA indication at VROF.

8. Contractor must furnish, install, wire, terminate and test the new digital VOIP telephone equipment at TES TPSS substation as shown on the Contract drawings. To support the telephone communications with central, these phones must interface the corresponding station Gigabit Network Switches. In case of local loss of power, to maintain uninterrupted telephone service, the substation VOIP telephone equipment must accept the local battery-backed power source.

9. The Contractor must furnish, install, configure/program and test all CTS LAN/WAN equipment to provide for interface between the SIP VOIP/Analog Converters and the Telephone System Head-End equipment in VROF. This interface must serve the needs of the phone equipment as well as needs of the PA messaging equipment. The Contractor must coordinate the IP addressing scheme, phone extensions scheme, LAN/WAN equipment settings, and the Telephone and PA equipment settings with VTA Communications Manager. Prior to the implementation, the final addressing scheme and the equipment settings must be approved the VTA.

10. As-built documentation and User Manuals will be provided by VTA that describes the existing telephone system. Any potential deviations from the existing system functions must be brought up to the attention of the VTA. The contractor must provide suggested resolutions to these issues for the VTA's approval.

11. Use of any component or device, not expressly specified herein, that is required to implement the Contractor's design, must be subject to required submittals for approval by the VTA.

2.02 ANALOG TELEPHONE INSTRUMENTS

A. Maintenance Dual-Mode Telephone Handsets (Platform & Communications Room MT): Each phone must be able to operate as both a DTMF dial-up telephone and as a source for making Public Address announcements at the corresponding station (the handsets must provide for both calling OCC and initiating ad hoc PA messages). The handsets and the appropriately sized locked boxes must be provided at each station as shown in the Contract Drawings.

1. The telephone instrument must operate over the temperature range of -30ºC to +60ºC and humidity of 0 to 95 percent.

2. Each telephone and the associated enclosure must be labeled with the extension number and other pertinent information as assigned by VTA. Labels must be resistant to peeling, fading or smudging. The label appearance and manufacturer must be approved by the VTA.

3. Electrical Parameters: Telephone sets furnished must meet or exceed the following specifications:

a. Power: Line powered. No internal battery must be required.

b. Impedance: 600 Ω (nominal).

c. Frequency Response: 300 Hz to 3 kHz.

d. Frequency Accuracy: +1.5 percent.

e. Signaling: DTMF.

f. Operation: Loop Start.

g. Supervisory DC Current: minimum 21 mA, maximum 80 mA.

h. Supervisory DC Voltage: 24 V(dc) to 60 V(dc), not polarity sensitive.

i. Talk Battery: 24 V –to 96 V (on ring).

j. Ring Voltage (Nominal): 105 V (ac), 20 Hz.

k. Ring Volume (Audio): Adjustable.

l. Noise Cancellation: 20 dB rejection.

4. Locked box enclosure (Platform MT):

   a. General: NEMA 4X, Heavy Duty, Cast Iron and Cast Aluminum, Vandal-Proof, Tamper-Proof housing. The Contractor is to work with VTA Operations & Maintenance regarding the recommended selection of the enclosures with the final model approval by the VTA.

   b. Key-Lock: Reinforced, heavy duty, all-metal "push-to-open" key-lock or clasp locking housing as approved by the VTA.

   c. Size: To fit the selected phone handset and the associated brackets/wiring.

   d. Telephone sets must be UL 1459 approved.

   e. Mounting: Pole-mounted with tamper-proof screws.

   f. Manufacturer: Allen Tel, Viking or approved equivalent.

5. 2-Line Corded Maintenance Phones (Platform MT):

   a. General: Suitable for outdoor installations in the selected locked box enclosures.

   b. Type: Corded Phone.

   c. Multi-Line Operation: 2 Lines Operation. The telephone must provide for clear identification to the end-user of which line/mode (MT or PA) is selected at the time of use.

   d. Dialer Type Keypad, minimum 12 button weatherproof DTMF pad.

   e. Features: Speakerphone.

   f. The telephone housing must be a high impact, anti-corrosive polyester enclosure resistant to thermal degradation and immune to chemicals, solvents, and salts.

   g. The telephone must contain a noise cancelling microphone. The noise cancellation microphone and circuitry must attenuate all background and ambient noise by more than 20 dB referenced to the speaker's voice level. The audible noise inside the substations will be limited to 70 dBa at 900 mm (3 ft.) away from each item of equipment.

h. Off-hook line impedance must be 600 Ω, either line. On-hook line impedance must be the ringer impedance on the PBX line, open circuit to ringdown line.

i. The talk battery voltage must be 24 V to 48 V (nominal) line.

j. Signaling to the dial-up line switching equipment must be via a DTMF push-button keypad. Loop signaling (FXO/FXS) must be utilized for PABX lines.

k. Telephones must have a highly durable retractile handset cord with a minimum length of 8 m (25 ft.).

l. Size: To fit the selected locked box enclosures.

m. Mounting: Wall-Mounted.

n. Manufacturer: Panasonic, AT&T, GE, or approved equivalent.

6. 2-Line Cordless Maintenance Telephones (Communications Room MT):

a. General: Digital, Spread Spectrum 5.8 GHz household or commercial cordless two-line telephone suitable for installations inside the station communication cabinets or communication rooms.

b. Type: Cordless Phone.

c. Digital Technology: FHSS.

d. Multi-Line Operation: 2 Lines Operation. The telephone must provide for clear identification to the end-user of which line/mode (MT or PA) is selected at the time of use.

e. Dialer Type Keypad, minimum 12 button DTMF pad.

f. Features: Speakerphone.

g. The telephone housing must be a high impact, anti-corrosive polyester enclosure resistant to thermal degradation and immune to chemicals, solvents, and salts.

h. The telephone must contain a noise canceling microphone. The noise cancellation microphone and circuitry must attenuate all background and ambient noise by more than 20 dB referenced to the speaker's voice level. The audible noise inside the substations will be limited to 70 dBa at 900 mm (3 ft.) away from each item of equipment.

i. Off-hook line impedance must be 600 Ω, either line. On-hook line impedance must be the ringer impedance on the PBX line, open circuit to ringdown line.

j. The talk battery voltage must be 24 V to 48 V (nominal) line.

k. Signaling to the dial-up line switching equipment must be via a DTMF push-button keypad. Loop signaling (FXO/FXS) must be utilized for PABX lines.

l. Wireless Handset Audio Quality and Range: The quality and the coverage distance vary greatly among cordless handsets. The Contractor must obtain 2-3 samples (recommended models) for cordless two-line phones and conduct preliminary field testing of these wireless handsets at 2-3 sample station locations selected by the VTA. Sample stations to consider must be 2-floor stations, stations with metal communication cabinets and stations with communication rooms. During these preliminary tests, the Contractor must try various placement of the phone base inside the communication room or the communication cabinet (with doors open and closed), while moving across the station platforms with the wireless handset and observing the quality and clarity of the audio connection based on the distance from the phone base and obstacles. The final model selection will be decided by the VTA based on the best area of coverage by the cordless handset.

m. Mounting: Wall-Mounted or Shelf-Mounted. For Shelf-Mounted installation the Contractor must submit shelf and mounting hardware details for the approval by the VTA.

n. Manufacturer: Panasonic, Motorola, ATT, GE, or approved equivalent.

B. Off-Platform Wall-Mounted Telephone Handsets (IT MT and Elevator): Off-Platform 1 line analog phones must operate as a single-line DTMF dial-up telephone to support phone calls by VTA personnel. To support the telephone communications with OCC and VROF, these phones must interface directly with the AT&T PSTN Network as individual POTS lines. The contractor must provide and install these telephone handsets at each station as shown in the Contract Drawings and at the following off-platform locations:

1. IT Rooms

2. Elevator Cabs

3. Communications Node locations or at each passenger station, as indicated on the Contract Drawings and not listed above.

C. Telephone sets furnished must meet or exceed the following specifications:

1. Power: Line powered. No internal battery must be required.

2. Impedance: Off-hook line impedance must be 600 Ω. On-hook line impedance must be the ringer impedance 600 Ω (nominal).

3. Frequency Response: 300 Hz to 3 kHz.

4. Frequency Accuracy: +1.5 percent.

5. Signaling: DTMF.

6. Operation: Loop Start.

7. Supervisory DC Current: minimum 21 mA, maximum 80 mA.

8. Supervisory DC Voltage: 24 V(dc) to 60 V(dc), not polarity sensitive.

9. Talk Battery: 24 V to 48 V (nominal) line and 24 V –to 96 V (on ring).

10. Ring Voltage (Nominal): 105 V (ac), 20 Hz.

11. Ring Volume (Audio): Adjustable.

12. Telephone type: 2500 type with 12 button DTMF pad.

13. Telephone housing:	High impact, anti-corrosive polyester enclosure resistant to thermal degradation and immune to chemicals, solvents, and salts. The telephone instrument must operate over the temperature range of -30ºC to +60ºC and humidity of 0 to 95 percent.
14. Noise canceling:	The noise cancellation microphone and circuitry must attenuate all background and ambient noise by more than 20 dB referenced to the speaker's voice level. The audible noise inside the substations will be limited to 70 dBa at 900 mm (3 ft.) away from each item of equipment.
15. Cord:	Telephones must have a highly durable retractile handset cord with a minimum length of 8 m (25 ft.).
16. Protecting equipment:	Protected terminal blocks and protectors, equipment terminal blocks, terminal block enclosures, inside communications conduit and raceway, cross connections, wiring to the telephone instrument, and telephone instruments as necessary to complete the connection of the telephone instrument to the CTS.

D. Elevator Telephone Instruments: The Contractor must ensure that all interfacing equipment, wire and termination are compatible with the conventional analog 1-line elevator intercoms. The Contractor is responsible for resolution of any equipment/wiring/termination/interface issues with the Elevator Contractor. The Contractor must ensure the communication wiring/cabling can endure without loss of functionality for the expected lifetime of the elevator equipment the elevator’s normal operation motion inside the elevator shaft. The elevator intercom phone lines must interface directly with AT&T POTS PSTN drops for ring-down service. The Contractor must provide off-hook status “Elevator Talkplate ON” for each elevator intercom, using normally open electrically isolated dry contact (provided by the Elevator Contract), for connection to the station PAC equipment (provided under this Contract) for SCADA indication at VROF.

2.03 VOIP TELEPHONE INSTRUMENTS

A. The Voice Over IP (VOIP) Single-line Telephone instruments must be installed at VTA station and wayside locations as shown on the Contract Drawings. The VOIP Telephones must support phone communications by the VTA personnel and must be powered from a local battery-backed source of power (e.g. at Traction Power substations). As a minimum, the VOIP Telephones must support all functions, featured by the existing phones used for the similar locations/applications at the existing VTA extensions. The new VOIP Telephones must be completely compatible with the VTA VOIP head-end at YMF and must not interfere with operations of the existing and new conventional analog telephone equipment.

1. Electrical rooms.
2. Mechanical rooms.
3. Elevator maintenance rooms.
4. Signal/Communications Rooms.
5. Operator Facility Break Rooms.
6. Traction Power Substations.
7. Signal Cases.

8. Communications Node locations or at each passenger station, at kiosks, as indicated on the Contract Drawings and not listed above.

B. Telephone sets furnished must meet or exceed the following specifications:

1. Power:
    a. Consumption: 1.7 W
    b. Adapter: Input Voltage: 125 V(dc), and 110 V (ac) 50-60 Hz
    c. Support for PoE (IEEE 802.3 af)

2. Voice QoS: Support for 802.1p/q for quality of service.

3. Frequency Response: 300 Hz to 3 kHz.

4. Ring Volume (Audio): Adjustable.

5. Compression: G.711 and G.729 compliant (as a minimum).

6. Regulatory Standards:
    a. EMC CLASS B (FCC-Part 15)
    b. Network FCC-Part 68 (US), CS-03 (Canada).

7. Voice Traffic: RTP over UDP.

8. MTBF Rate: 10 yrs.

9. Weight: 1.7 lbs.

10. Ethernet: IEEE 802.1p/q.

11. Protocol: SIP compliant (as a minimum).

12. Telephone housing: High impact, anti-corrosive polyester enclosure resistant to thermal degradation and immune to chemicals, solvents, and salts. The telephone instrument must operate over the temperature range of 0ºC to +60ºC and humidity of 0 to 95 percent.

13. Noise canceling: The noise cancellation microphone and circuitry must attenuate all background and ambient noise by more than 20 dB referenced to the speaker's voice level. The audible noise inside the substations will be limited to 70 dBa at 900 mm (3 ft.) away from each item of equipment.

14. Cord: Telephones must have a highly durable retractile handset cord with a minimum length of 8 m (25 ft.).

C. The following Trunking standards must be supported:
1. G.711 and G.729 compression
2. RFC 3261 – SIP Session Initiation Protocol
3. RFC 3262 – Reliability of provisional responses in session initiation protocol (SIP)
4. RFC 3263 – Locating SIP servers
5. RFC 3264 – An offer answer model with session description protocol
6. RFC 3515 – The session initiation protocol (SIP) refer method
7. RFC 2976 – The SIP info method
8. RFC 3325 – Private extensions to the session initiation protocol (SIP)
9. RFC 1321 – The MD5 message digest algorithm
10. RFC 2833 – RTP payload for DTMF digits, telephony tones and telephony signals (section 3.10)

D. The following SIP Line Side standards must be supported:
   1. RFC 1321 – The MD5 message digest algorithm
   2. RFC 2976 – The SIP info method
   3. RFC 3261 – SIP Session Initiation Protocol
   4. RFC 3262 – Reliability of provisional responses in SIP
   5. RFC 3263 – Locating SIP Servers
   6. RFC 3265 – Specific event notification
   7. RFC 3311 – The Session initiation protocol update method
   8. RFC 3515 – The Session initiation protocol refer method
   9. RFC 3891 – The Session initiation protocol replaces header
   10. RFC 4028 – Session timers in the session initiation protocol
   11. RFC 3680 – A session initiation protocol event package for registrations
   12. RFC 3842 – A message summary and message waiting indication event package for SIP
   13. RFC 2327 – SDP: Session description protocol
   14. RFC 3264 – An offer / answer model with SDP
   15. RFC 2833 – RTP payload for DTMF digits, telephony tones and telephony signal

E. The Contractor must provide, install and terminate all miscellaneous equipment, not specifically mentioned above, as necessary for proper end-to-end (field to VROF) VOIP telephone communications, such as CAT6 and fiber-optic cabling/equipment, power AC/AC or DC/AC converters, media converters, protection equipment, and related equipment.

F. The VOIP Telephone equipment must be a Mitel 5000 series or approved equal.

2.04 MISCELLANEOUS TELEPHONE EQUIPMENT

A. Outlets:
   1. For conventional analog phones, six-position, four conductor modular connectors and outlets must be furnished at all wall-mounted telephone locations. The outlets must be rated for category 3 performance (cable to outlet remains category 6) and must meet FCC CFR 47 part 68 subpart F, and IEC 603 7 requirements. Connector contacts must have 1.27 µm (50 micro-in.) minimum of gold plating over nickel. Outlet and connector connections must be in accordance with the USOC RJ-14 for 2-pair wiring.

   2. For VOIP phones, the Contractor must furnish and terminate couplers for RJ-45 connectors at all such telephone locations. The outlets must be rated for category 6 performance and must meet FCC CFR 47 requirements. Connector contacts must have 1.27 µm (50 micro-in.) minimum of gold plating over nickel.

   3. Each outlet must be labeled with the corresponding extension number. The label must be resistant to peeling, fading, or smudging.

B. Terminal Blocks: Terminal block assemblies installed must be 12 pair protected terminal blocks. Terminal blocks must be equipped with 2-electrode screw-in gas tube arrestors.

C. Conduit: The Contractor must utilize conduit as shown in the Contract Drawings.

D. Labels: Each telephone and the associated enclosure must be labeled with the extension number and other pertinent information as assigned by VTA. Labels must be resistant to peeling, fading or smudging. The label appearance and manufacturer must be approved by the VTA.

E. Fiber Cables and Media Converters: The Contractor must provide, wire and terminate media converters either as shown on the Contract Drawings; or for all communication interfaces where it was determined that the communication runs exceed allowed distances or local EMI levels precludes communications over the copper media. To identify such runs, the Contractor must utilize the industry guidelines and the manufacturer recommendations. For such runs, the contract must use fiber cables and matching media converters on each end. The Contractor is ultimately responsible for ensuring the reliability and availability of all communication interfaces used by the current Contract. The fiber cable and media converter equipment must be approved by the VTA.

2.05 VOIP TO ANALOG CONVERTERS

A. This adapter must support a minimum of four DTMF RJ-11 analog ports for connection of standard telephone devices. Single our dual port adapters may be required for compatibility with the existing VTA system and must be provided if necessary.

B. The adapters analog ports must supply standard line power to each Telephone device connected.

C. The adapter must be connected to the station UPS system to provide power to the Telephone devices and connectivity to the PABX during loss of power at the station.

D. The adapter must support SIP for sending voice over Internet Protocols.

E. The adapter must support the following standard protocols SIP, RTP, RTCP, SMTP, Q.931, T.38 & Group 3 Fax relay, SNMP V-1, V-2 and V-3.

F. The adapter must support the following features:

1. DTMF out-of-band (RFC 2833).
2. Supports FXS/FXO on each channel for direct analog connection to phones, key telephones, fax machines, PBX extensions, PSTN lines or PBX trunks.
3. Provides local office survivability in the event of a LAN/WAN failure.
4. Emergency transfer (power-out fail-over).
5. PSTN trunking bridges the PSTN to the IP network for emergency calls as well as normal inbound/outbound calling.
6. Multi-port ATA functionality for analog phones and fax machines.
7. Ethernet connectivity and full IP compatibility with existing routers and WAN infrastructure with RJ-45 10/100 base T port.
8. Voice compression to 5.3K bps per call with support for multiple algorithms, including ITU G.723 and G.729.
9. VAD and CNG support.
10. QoS via DiffServ or 802.1p.
11. T.38 real-time fax relay for interoperability among other VOIP equipment.
12. Supports SIP supplementary services including call forward, call transfer, and call hold.
13. Adaptive echo cancellation, forward error correction and dynamic jitter buffers.

14. Configuration and management using a Web browser or Windows.

15. Two-year warranty.

    a. The Analog to VOIP adapter must be demonstrated to interoperate with the selected VOIP Gateway.

    b. The adapter must be of a professional telecommunications carrier class quality not made for the home use market.

    c. The Analog to VOIP adapters must be the Multinet MVP410-SS or approved equal.

2.06 STATION WIRE

A. Station wire must be in accordance with the requirements of the Section 27 13 00, “Communication Network Cabling,” and must be Category 6 unless otherwise noted.

2.07 MISCELLANEOUS EQUIPMENT

A. The Contractor must furnish and install all miscellaneous equipment to complete the Telephone and LAN/WAN subsystem. This must include surface conduit between station junction boxes and telephone subsystem equipment; LAN/WAN Equipment (not specifically mentioned above, but necessary to make a fully functional system), and miscellaneous mounting hardware for telephone and network equipment in VROF, Communication Nodes or station locations.

2.08 CONNECTION OF EXTENSIONS TELEPHONE LINES TO THE PABX

A. The Contractor must coordinate the installation and testing of the Extensions telephone lines with the VTA.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General: The contractor must implement the following:

1. Preparation:

    a. The Contractor must coordinate telephone extensions with the VTA.

    b. With VTA support, the Contractor must measure and record the end-to-end 1 kHz loss from the line test interface to the telephone outlet, for each instrument.

2. Mounting and Connection:

    a. Prior to connecting circuits, measure, with a VOM, the voltage on the pairs to verify that no voltage hazardous to the PABX, or VOIP modules must be connected.

    b. Make terminations and connections in a neat and workmanlike manner utilizing tools appropriate to the termination equipment or block type.

    c. The Contractor must install outdoor telephone subsystem wiring from the disconnect blocks servicing new Analog Telephones and SIP VOIP/Analog Converters to Analog Telephones through protective entrance terminals.

3. Instrument Wiring:

a. The Contractor must install raceway from the stubbed communication conduits coming from the local distribution frame, the local distribution frame enclosure, to each telephone instrument location. Conduit routing must avoid other equipment and heat sources and must be approved by the VTA. Pull strings must be installed within the conduits and tied off.

b. All cables must be installed in overhead cable tray in the communications rooms. Cables and cross-connect wiring must be bundled neatly and restrained with dielectric ties to facilitate tracing of wiring.

c. Telephone outlets must be installed at the approved locations utilizing mounting screws. Adhesive mounts will not be used, unless approved by the VTA for a specific location.

d. The Contractor must use care to avoid damaging telephone cabling during installation.

e. Install all required cross-connections in a manner to insure tip/ring continuity, without reversals, between the instrument and the VOIP Modules for MPOE.

3.02 TESTING

A. Telephone Factory Testing: The following factory tests must be performed:

1. Audio performance.
2. DTMF signaling.
3. Ringdown off-hook signaling.
4. Ringer impedance and operation.

B. Field Testing of all stations Telephones included under the current contract: The following field tests must be performed after installation is complete and the communication backbone and the associated nodes are fully functional:

1. Verify audio continuity from instrument to control center for both lines. Set transmission level points appropriately.
2. Verify DTMF signaling end-to-end.
3. Verify correct VOIP routing.
4. Verify off-hook signaling to control center.
5. Test ground impedance.
6. Measure and record the end-to-end 1 kHz loss from the line test interface to the telephone outlet, for each instrument.

C. Integration Testing of all stations Telephones included under the current contract: The following tests must be performed after competition of the field testing:

1. Verify end-to-end proper network VLAN/routing, IP interfaces between field nodes and the head-end equipment.
2. Verify On/Off hook status is recognized by the phone system and dial tone provided when off-hook. Confirm the elevator “Talkplate ON” indication at the SCADA Remote I/O unit.

3. Verify switch-hook flash signaling is recognized by the PABX.

4. Verify the telephone rings when called.

5. Verify dialed digits are correctly interpreted by the VOIP and PABX equipment.

6. Verify the telephone extension is correctly labeled on the outlet.

7. Verify local announcements can be made using the wired and wireless maintenance phones. Confirm SCADA indications for the PA announcement indications at the central.

8. Verify the correct identification of the OCC call and Local PA identification for the wired and wireless maintenance phones.

3.03 FIELD QUALITY CONTROL

A. Quality: The quality of the Communications System installation must be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications and workmanship standards and practices.

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SECTION 27 42 19

PUBLIC ADDRESS SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes the requirements of the Public Address (PA) system at the two new LRT stations. The PA system provides train destination information and emergency messages to passengers, employees, and emergency response personnel. Communications to the stations must be from the Operations Control Center (OCC) located in the Younger Maintenance Facility (YMF). Each station must also have the capability for locally generated PA announcements. Communications must be from YMF to stations or groups of stations. Each center platform station must be capable of supporting OCC-generated PA announcements specific to each platform edge of the center platform (Two separate messages).

1.02 RELATED SECTIONS

A. Section 6.6.2, Submittal, of the Special Conditions

B. Section 01 78 23, Operation and Maintenance Data

C. Section 27 05 00, Common Work Results for Communications

D. Section 27 05 28, Pathways for Communications Systems

E. Section 27 11 16, Communications Cabinets, Racks, Frames and Enclosures

F. Section 27 11 19, Communications Terminal Blocks and Patch Panels

G. Section 27 13 00, Communications Network Cabling

H. Section 27 15 00, Communications Low-Voltage Conductors and Cables

I. Section 27 21 00, Communications Network Equipment

J. Section 27 26 00, Communications Programming and Integration Services

K. Section 27 30 00, Telephone System

L. Section 27 42 20, Passenger Information Monitor System

M. Section 28 40 00, SCADA Monitoring and Control System

1.03 REFERENCED STANDARDS

A. The latest versions of the following standards and references apply to the work included in this Section, in addition to those codes and standards common to all communications subsystems specified in section 27 05 00 “Common Work Results for Communications”. If a conflict must arise between various standards, the California state code amendments must govern, or the most strict/conservative requirement must govern.

B. Americans With Disabilities Act (ADA).

C. Building Industry Consulting Services International (BICSI):

1. TDMM Telecommunications Distribution Methods Manual.

D. Electronic Industries Association (EIA):

1. SE-101-A Amplifiers for Sound Equipment.
2. SE-103 Speakers for Sound Equipment.
3. SE-104 Engineering Specifications for Amplifiers for Sound Equipment.
4. 160 Sound Systems.

E. Federal Communications Commission (FCC).

F. National Fire Protection Association (NFPA):

1. 70 National Electrical Code.
2. 72 National Fire Alarm and Signaling Code.
3. 130 Standards for Fixed Guideway Transit and Passenger Rail Systems.

G. California Building Code (CBC).

H. California Electrical Code (CEC).

I. Santa Clara County District Standards.

J. City of San Jose Standards.

K. Local Noise Ordinances.

1.04 SUBMITTALS

A. Preliminary Design Review: The Contractor must submit the following information as part of the PA/PIM Preliminary Design Review submittal:

1. Preliminary design to prevent feedback for local station announcements.
2. Preliminary design of Maintenance Telephone / local PA dual-mode wired and wireless handsets.
3. Preliminary design of any required network configuration and interfaces.
4. Description including catalog cuts of the equipment to be installed.
5. Mechanical interface design of speakers, telephones and microphones to station elements.
6. PA coverage calculation for side platform configuration and center platform configuration for standard 92 m (300 ft.) long platforms.
7. Preliminary design of the SCU/PDAC and the associated hardware/software necessary for implementation of the PA announcements.

8. Preliminary design of the software and database upgrades at the YMF SCADA/Alstom PA/CIS head-end necessary for implementation of the PA announcements at the 2 new stations.

B. Cutover Plan: The Contractor must submit a Cutover Plan submittal package. Contractor must proceed with the equipment cutover only after approval of the Cutover Plan. The VTA will assign cutover dates and times for each station.

C. Final Design Review: The Contractor must submit a Final Design Review submittal package. The final design review package must include the final design of all components and interfaces of the system and must incorporate all comments made by the VTA during the Preliminary Design Review and Cutover plan submittals.

D. Installation Drawings: The Contractor must submit installation drawings. Contractor must proceed with the installation only after approval of the installation drawings.

E. Test Reports: Prior to the beginning of testing, the Contractor must submit the test plan and the test procedures for approval by the VTA. Each test procedure must clearly identify the time, test equipment, location, equipment/function tested and the pass/fail criteria. The Contractor must submit the results of the testing within 15 days after conclusion of the testing. In addition to the test signed by Contractor representatives, all tests must also be witnessed and signed off by VTA representatives. Test plan procedures and reports shall be submitted for (see definitions in general testing requirements section TBD):

1. Factory Acceptance Tests
2. Field Installation Tests
3. Field Functional Tests
4. Systems Integration Tests (Per Station)
5. Systems Integration Tests (to OCC)

F. As-built documentation: Within 6 weeks after the equipment and the functionality of the new system is verified and accepted by VTA, the Contractor must submit the as-built drawings and configuration as-built settings of the implemented system.

G. Operations and Maintenance Manuals as defined in Section 01 78 23, Operation and Maintenance Data.

1.05 QUALITY ASSURANCE

A. The Contractor must provide sample telephones to the Resident Engineer for approval.

B. All components must be UL listed.

C. The Contractor must coordinate with the Station elevator contractor for details of routing communications cabling to the supplied telephone interface.

1.06 MEASUREMENT AND PAYMENT

A. Measurement: Communications Low-Voltage Conductors and Cables must be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Communications Low-Voltage Conductors and Cables must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in this Section complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Scope: The Contractor must design, furnish, install and test equipment and software upgrades for the Public Address (PA) subsystem at 2 new LRT stations. The PA and PIM system provides train destination information and emergency messages to passengers, employees, and emergency response personnel. Communications to the stations must be from the Operations Control Center (OCC) located in the Younger Maintenance Facility (YMF). Each station must also have the capability for locally generated PA announcements. Communications must be from YMF to stations or groups of stations. Each dual platform station must be capable of supporting the future OCC-generated platform-specific PA announcements, but will be temporarily wired for common messages for the entire station as specified.

2.02 DESIGN REQUIREMENTS

A. General

1. The contractor must implement all necessary changes required to the hardware and software at the head-end located at the VTA Younger Maintenance Facility (YMF) and at the stations described below to provide for a fully functional PA and Telephone system. The contractor must ensure that there will be no loss of the existing system functionality.

2. The Contractor must design, furnish, install, and test equipment and software upgrades to PA equipment at the following stations:

   a. Story

   b. Eastridge

3. The PA equipment must include Public Address Controllers (PAC), mixers/ambient noise compensators, feedback eliminators, power amplifiers, ambient noise sensing microphones, speakers, cabling, and all other equipment defined in these technical specifications and the Contract Drawings.

4. The Contractor must provide for dual-mode Maintenance telephone equipment, as defined in section 27 30 00, Telephone System.

B. Passenger Station Public Address (PA) design:

1. The PA subsystem must provide four separate “addressable points” at center platform stations Story and Eastridge. This must allow the Operations Control Center (OCC) to make announcements to individual boarding platform edges, as opposed to announcements heard at both Northbound and Southbound platform edges simultaneously. This will also reduce the level of ambient “noise” generated by LRT stations in residential neighborhoods. The PA subsystem must allow field personnel to make local announcements using maintenance telephone equipment located on the platforms and in the communications room.

2. The PA subsystem field devices must accept the PA messages from the new field PA Controller (PACs). The existing PA system currently utilizes the existing SCUs located at the Alstom PA/CIS (PA/CIS) Subsystem Rack in the Younger Maintenance Facility SCADA Equipment Room. These SCUs are a part of the Alstom PA/CIS (PA/CIS) subsystem and are controlled by the Alstom PA/CIS servers over the SCADA OCC LAN network. The existing SCUs currently supply the passenger stations with the PA messages via the SCADA WAN. With the exception of the station SCUs for the Guadalupe corridor 13 Southline stations, each existing SCU currently serves multiple passenger stations. Under the current project, the contractor must provide one new SCU at the YMF SCADA Equipment Room as shown on the Contract Drawings. VTA must program/configure the new Contractor supplied SCU (and all other pertinent elements of the Alstom PA/CIS system) so that each new passenger station would be monitored and controlled by the new SCU installed at the YMF (the station's PA will be generated by the new YMF SCU). The contractor must utilize the SCADA WAN Network for the backbone communications between the new field PACs and the Alstom PA/CIS/SCADA Head-End equipment at the YMF. VTA will implement the Alstom PA/CIS/SCADA Head end software, and the Contractor must implement the hardware and provide and test network elements necessary to reach the new EBRC passenger stations. The Contractor must refer to the VTA S945 project's design documents, as-built documents and user manuals for a description of the existing Alstom PA/CIS System functionality and guidance for Contractor required hardware configuration changes.

3. For the dual edge, center platform stations for the EBRC, the PA Subsystem must utilize the analog audio output of the PA Controller (PAC) installed by the Contractor at each station. The PAC Controller must accept digital audio output from the new SCU at YMF transmitted to the PAC over the SCADA WAN.

4. The PA subsystem must provide an anti-feedback system for the local maintenance telephone/microphone input for the PA channel at each station. This system prevents the loud, high-pitched "ear piercing," and sometimes equipment damaging, feedback sound caused when an announcement is made locally at a platform and the telephone/microphone picks up the announcement from the closest speakers.

5. The PA subsystem must provide an Automatic Gain Control and Digital Signal Processor (DSP) system at each platform. This system must automatically adjust the volume of the announcement being made so that it can be clearly heard by patrons despite the varying level of ambient noise surrounding the stations. This system must raise the volume when there is a lot of ambient noise, and lower the volume when ambient noise is not present, so as to reduce noise complaints from neighboring residents. The integrated DSP must allow for fine tuning of the system to provide optimum clarity of announcements.

6. The PA subsystem must provide a local PA announcement feature at all new stations. This feature must enable maintenance personnel, Train Operators, Transit Supervisors, Sheriff, VTA ambassadors, etc. to make local PA announcements from the maintenance telephones located on the platforms or from the handset telephones located inside the communication room at each station.

7. Local (live) PA announcements must be initiated from a dual-mode maintenance telephone handset located in vandal-proof locked boxes as shown in the Contract Drawings. The handset must have two lines: a Maintenance Telephone (MT) mode line, and a Public Address (PA) mode line. In making a telephone call, the end-user will select the MT mode line and make the telephone call. In making a local announcement, the end-user will select the PA mode line and make an announcement. The telephone equipment must provide for clear identification to the end-user of which mode (MT or PA) is selected at the time of use.

8. Local (local) PA announcements must also be initiated from local Digital, Spread Spectrum 5.8 GHz household or commercial cordless two-line telephone located inside the Station Communication Room. This must be accomplished in a manner consistent with the wired handset maintenance telephones located on the platform. However, a 9 VDC power supply (or as required for the specific telephone) must be provided as needed. The handset must have two lines: a Maintenance Telephone (MT) mode line, and a Public Address (PA) mode line. In making a telephone call, the end-user will select the MT mode line and make the telephone call. In making a local announcement, the end-user will select the PA mode line and make an announcement. The telephone equipment must provide for clear identification to the end-user of which mode (MT or PA) is selected at the time of use.

9. The PA subsystem must provide intelligible output coverage at a level 6 dB to 12 dB over normal train, equipment, and public noise. Nominal Sound Pressure Level (Sensitivity**)** must be 77 dBA +/- 3dBA at 1500 mm (5 ft.) above floor level. On station platforms, the coverage must be a uniform level (+/- 3 dB) over 90 percent of the open platform area. Nominal Sound Pressure Level must be no less than 60 dBA over 100 percent of the platform area.

10. PA Announcements from YMF: Operations personnel must initiate PA announcements from YMF. These announcements will be PA only announcements. PIM message integration will be provided by VTA, which consists of a manual Standard Operating Procedure (SOP), to make coordinated equivalent PIM announcements as required by the NFPA 130 and ADA, whenever a scheduled or ad-hoc PA announcement is made from the OCC. The VTA Customer Service department creates and sends the equivalent PIM messages during normal business hours. The VTA Rail Operations at the YMF OCC also creates and sends the equivalent PIM messages before and after normal business hours. There is no system software level connection between the PIM subsystem and the PA subsystem.

11. PA announcement Priority: The priority of PA announcements at individual stations is as follows:

    a. Local PA announcements.

    b. PA announcements from OCC.

12. Local PA announcements must preempt PA announcements from YMF.

13. The PA subsystem must provide an indication input to the Communication Node PAC when a local announcement is being generated, through contact closure to SCADA from the PA system.

14. PA Equipment Faults: The PA subsystem must detect failure of PA equipment or loss of any single speaker or output channel (as shown in the Contract Drawings) and must provide an indication input to the Communication Node PAC.

15. PA Acoustic Feedback: The Contractors design must prevent acoustic feedback from local PA announcements.

16. Sound Level Adjustment: The PA subsystem must monitor the ambient sound level at Stations and automatically the increase the output level of the power amplifiers. Sound pressure levels must be maintained at least 6dB but not more than 12 dB above the ambient noise level.

17. PA Tone Alert: In the case of emergency announcements, the PA Controller must issue a tone alert before an announcement is made. The tone alert must be a multi-frequency tone provide by VTA.

C. Head-End Alstom PA/CIS PA Subsystem design:

1. VTA will reprogram the existing Alstom PA/CIS System; the corresponding existing SCADA databases; the existing LAN/WAN/Firewall equipment and the new PA SCU at the YMF (and related pertinent elements of the existing VTA communications system) so that each new passenger station would be monitored and controlled by the new YMF SCU. VTA will remove the existing Variable Message Board (VMB) sign programming and configuration from the Alstom PA/CIS System. The Alstom PA/CIS System will be for delivery of PA messages only to passenger stations.

2. The Contractor must configure the YMF SCU, LAN/WAN equipment, PA Controllers and all other related PA, Telephone and ethernet network equipment provided by the Contractor to provide for a secure bridge for the PA messaging traffic to and from the YMF OCC and River Oaks.

3. The Contractor must refer to the VTA S945 project design documents and manuals for description of the existing Alstom PA/CIS functionality and guidance for required hardware configuration changes.

2.03 PA EQUIPMENT

A. General: The Public Address equipment must meet the following general requirements:

1. Solid state design.
2. Latest manufacturer model.
3. Rack-mountable.
4. UL listed.

B. Priority Selection: Priority selection must conform to the following:

1. Minimum of 4 audio inputs with 4 levels of priority.
2. Input activation by contact closure or voice activation.
3. Balanced input and output.

C. Pre-Amplifiers/Mixers: Pre-amplifiers/mixers must conform to the following:

1. Line and Microphone inputs.
2. Analog and digital inputs.
3. Rack mountable without shelf mounting.
4. Programmable input prioritization.
5. Transformer isolated inputs and outputs.
6. Frequency Response: 20 Hz to 20 kHz, +0.25 dB, -.25 dB.
7. Harmonic Distortion: 0.35 percent maximum.
8. Noise; -72 dB below.
9. Gain Adjust: 0 to 34 dB.
10. Externally programmable via a locally connected Laptop PC with PA vendor software supplied.

11. Contractor must supply commercially available software from the PA vendor, for PA diagnostics and configuration.

12. The laptop for maintenance programming of the audio units must be supplied by the owner. The laptop for initial programming and testing must be provided by the contractor.

13. The unit must include the CobraNet compliant Card.

14. Multi-Function Control Port must implement analog and digital I/O for control and monitor by external circuits

15. The pre-amplifier/mixer must be the BSS Audio BLU-100 Digital Signal Processor / Mixer or approved equal.

D. Automatic Level Control: The Automatic Level Control, integral with the Pre-amp/Mixer Unit must conform to the following:

1. Continuous sampling of ambient to provide a zero time delay for announcements.

2. Automatic adjustment range: 0 to 19 dB.

3. Sense Channel: 250 Hz to 4 kHz +/- 1 dB.

4. Expander attack and release times: 3 to 25 seconds adjustable attack time and 15 to 120 seconds release time.

5. Sense hold on announcement.

6. Microphone sense for gain adjustment circuit.

E. Audio Power Amplifiers: Power amplifiers must conform to the following:

1. Frequency response: 20 Hz for 20 kHz flat +/- 0.5 dB at rated output.

2. Harmonic Distortion: Less than 0.35 percent at rated output.

3. Output: Constant 70 V nominal, transformer isolated.

4. Overload protection: Current limited, thermal overload.

5. Power capacity: 50 percent greater than power output at nominal Sound Pressure Levels.

6. Front Panel Controls: ON/OFF Switch.

7. Front Panel Indications: LED ON/OFF Indicator lamp.

8. Rear Panel Controls: Level controls, and circuit breaker.

9. Convection or fan cooling.

10. The unit must be rack mountable without using shelf mounts.

11. The unit must be equipped with the IQ-PIP module IQ-PIP-USP3/CN or approved equal to allow failure detection and signaling.

12. The Audio Power Amplifier must be a Crown DCi 4 Channel 1250N amplifier or approved equal.

F. Failure Detection: Unit failure and speaker or channel failure must be detected by the addition of the IQ-PIP module which must result in a contact closure monitored by the Communication SCADA PAC.

G. Dual-Mode Handsets: Refer to Section 27 30 00, "Telephone System" for description of the 2-line wired (corded) and 2-line wireless (cordless) Dual-Mode Handsets and the associated enclosures.

H. Speakers: Speakers must conform to the following:

1. Physical characteristics:

   a. 200 mm (8 in.) diameter.

   b. Vinyl impregnated cloth with treated edge suspension and curvilinear body for waterproofing. Treated paper tweeter cone.

2. Electrical characteristics:

   a. Flux density: 1 T.

   b. Rated impedance: 8 Ω.

   c. Rated power: 15 W (RMS).

   d. Input transformer: Match 70.7 V line to speaker impedance with taps for .5, 1, 2, 4, and 8 W.

3. Acoustical characteristics:

   a. Sound Pressure Level (Sensitivity): 93 dB at 1 W/m, referenced to 0.02 mPa.

   b. Resonance: 90 Hz.

   c. Frequency response: 50 Hz to18 kHz.

   d. Crossover frequency: 3 kHz.

4. Misco (Minneapolis Speaker Company) JC8WP speakers or approved equivalent.

I. Matching Transformers: Transformers must conform to the following:

1. Insertion Loss: 0.5 dB maximum.

2. Frequency response: 40 Hz to 10 kHz, +/- 1 dB.

3. Distribution: multi-tapped to meet nominal Sound Pressure Levels.

4. Power rating: 15 W continuous.

5. Misco 8HT70 Line Transformer or approved equivalent.

J. Ambient Noise Sensing Microphones: Microphones must conform to the following:

1. AKG PZM-11 II WR, DBX AFS2 microphones or approved equal.

2. Element Type: Dynamic.

3. Polar Pattern: Hemispherical.

4. Frequency Response: 80 Hz to 10 kHz.

K. Feedback Exterminator: Feedback Exterminator must conform to the following:

1. Sabine Feedback Exterminator FBX1200 or approved equal.

L. PA Equipment Cables: The PA Cables must conform to the requirements outlined in Section 27 15 00, "Communications Low-Voltage Conductors and Cables."

1. PA speaker cables must be minimum #14 AWG (or as identified on the Contract drawings or as required by the Contractor's design) twisted pair with shield. PA speakers must be independently wired as shown in the Contract Drawings. The Contractor must take care to ground the cable shields at the Communications Node/Room only.

2. Speaker Cable must meet the following characteristics:

a.	Jacket:	NEC CL2P, Low Smoke.
b.	Wires:	Uniquely Color Coded.
c.	Cable Type:	Stranded twisted pair.
d.	Shield:	Individually foil shielded pairs each with a tinned-copper drain wire. One 100% coverage overall foil shield, with a braided shield minimum.
e.	Capacitance:	≤13 pf/ft.
f.	Resistance:	≤30 ohms/1000 ft.

3. Ambient noise microphone power cable must be single pair minimum 18 AWG (or as identified on the Contract drawings or as required by the Contractor's design) stranded twisted pair with shield suitable for outdoor installations.

4. Ambient noise microphone analog audio cable must meet the following characteristics:

a.	Jacket:	NEC CMP, Low Smoke.
b.	Suitability:	Outdoor
c.	Wires:	Uniquely Color Coded.
d.	Cable Type:	Shielded twisted pair.
e.	Total Number of Conductors:	2.
f.	Conductor gauge:	Minimum 18 AWG stranded
g.	Nom. DC Resistance:	≤ 15 ohms/1000 ft.
h.	Nom. Capacitance:	≤ 50 pF/ft (Conductor to Conductor @ 1 KHz)

i. AKG PZM-11 II WR, DBX AFS2 or approved equal.

M. Station Control Unit (SCU):

1. The SCU interfaces with the Alstom PA/CIS Public Address System and servers and software, to deliver audio for up to 16 passenger stations via the Dante audio protocol, for digital delivery of audio to passenger stations.

2. The existing SCUs are Expanding Dragon 1U servers, with Alstom PA/CIS server software running on MS Windows 2012. Contractor must provide a compatible 1U server, with MS Windows 2012, or more current MS Windows operating system as required by Alstom PA/CIS as currently upgraded by VTA, Alstom PA/CIS servers software and licenses, along with per station licenses for 16 additional passenger stations.

3. Provide sufficient RAM memory and data storage to accommodate the 16 passenger stations as required by Alstom PA/CIS.

4. The SCU must deliver digital Dante audio to the PA Controller for annunciation on the Public Address system at each new EBRC passenger stations.

5. The single SCU at YMF must provide all audio content for the two new EBRC station, with spare capacity for 14 more stations without addition of hardware or software.

N. PA Controller:

1. The PA Controller accepts digital audio input delivered across the CTS from the YMF new Station Controller, and converts it to analog audio for delivery to the PA Mixer.

2. The PA Controller must meet the following requirements:

   a. Compatible with the Audinate/Dante audio protocol for ethernet delivery of audio from the new Contractor supplied SCU at the YMF.

   b. Multi-channel digital media networking.

   c. Near-zero latency and synchronization.

   d. Configurable as unicast or multicast.

   e. One channel or two channel analogue output.

   f. Durable overmolded housing.

   g. Resilient cable strain relief.

   h. RJ45 metal connectors with integrated LEDs.

   i. AX Series XLR connectors.

   j. Supports 802.3af POE power source.

   k. Supply any required server, workstation or device licenses, configure equipment for audio delivery.

O. Fasteners: All fasteners accessible to VTA patrons or the general public must be stainless steel and tamper-resistant. Tamper-resistant fasteners, such as bolts or screws or other types, must be installed or removed by special tools supplied by this Contract.

P. Miscellaneous Equipment: The Contractor must furnish and install all miscellaneous equipment to complete the PA subsystem. This must include surface mounted conduit between station junction boxes and PA subsystem equipment, and miscellaneous mounting hardware for PA equipment in the YMF, Communication Nodes or Speaker Housings.

PART 3 - EXECUTION

3.01 INSTALLATION

A. The contractor must implement the following at the stations:

1. General: The Contractor is to install, terminate, program and label the PA equipment as shown on the Contract Drawings and as described below. The Contractor is to perform all necessary configuration of the PA Subsystems to allow VTA programming of the PA Subsystems. Contractor must terminate its digital input (dry contact) alarms from PA equipment to the corresponding inputs of the SCADA PAC. The Contractor is responsible for implementation of a fully functional PA system.

2. Add, terminate and program a Station Control Unit (SCU) assembly at the YMF Equipment Room.

3. Add, terminate and configure/program a PA Controller at each station.

4. Install speaker wire runs to all new speakers. The new speaker wiring must be installed as follows:

    a. Dual Platform station shelters - wire channels “1 and 2” of the PA amplifier to the speakers located on the Northbound platform; wire channels “3 and 4” of the PA amplifier to the speakers located on the Southbound platform. This must enable platform-specific announcements at these stations based on PA announcements sent from OCC to the channel “1 & 2” or “3 & 4” depending on the direction of the train travel.

    b. Dual Platform station light poles - wire channels “1 and 3” of the PA amplifier to the speakers located on the poles north of the station shelters; wire channels “2 and 4” of the PA amplifier to the speakers located south of the station shelters. Platform-specific announcements shall not be made from light pole mounted PA speakers.

    c. Provide and install temporary jumpers to combine outputs for Line 1 and Line 3, and Line 2 and Line 4, until the PA software is configured by VTA for 4 channels instead of the normal 2 channels utilized at existing VTA stations.

    d. Provide appropriate labeling on all cables. The Contractor is to submit wiring, volume setting and labeling details for the speakers, PA amplifier channels “1” through “4” for the approval by the VTA.

5. Install new speakers, in new speaker housings (provided by others).

6. Ensure all speakers are aimed in line with the platform, not facing at right angles to the platform centerline, adjust if necessary. Provide channel labeling on housing as approved by the VTA.

7. Provide, install and wire a Line Transformer for each speaker.

8. Provide, install, wire and program one Feedback Exterminator at each station. Provide labeling on units as approved by the VTA.

9. Provide, install, wire and program one Digital Signal Processor / Mixer or approved equivalent at each station. Provide labeling on units as approved by the VTA.

10. Provide, install and wire two microphones per station as shown on the Contract Drawings to be used as Ambient Noise Sensors. For the microphone’s 24 VDC power, utilize the new PLC 24VDC Power Supply terminated at the PLC Terminal Block inside the communication room. Provide labeling on units as approved by the VTA.

11. Provide, install, wire and program one four channel power amplifier per station   Provide labeling on units as approved by the VTA.

12. Provide, install and wire the 2-Line Maintenance Corded/Fixed Phones. The Contractor is to install these phones inside the corresponding Locked Box assemblies as shown on the drawings. The Contractor is to provide, install and mount the Locked Box Assemblies on the light poles by others.

13. Provide, install and wire the 2-Line Maintenance Cordless/Wireless Phones within each station signal/communication room. The phone's power supply must be provided and terminated as needed.

B. The contractor must implement the following at the Younger Maintenance Facility (YMF): Install and configure the new Station Control Unit, and provide troubleshooting and testing support to VTA.

C. Provide, install and terminate proper grounding and protection equipment for all outdoor cabling entering the communication rooms or other enclosures. Provide proper grounding for the new equipment and wiring installed inside the communication rooms. Contractor is to submit grounding and protection equipment details for the approval by the VTA.

3.02 TESTING

A. PA Subsystem: The Contractor must perform the following tests:

1. Demonstrate PA equipment fault supervision.

2. PA Subsystem SCADA Integration Tests: The Contractor must perform end-to-end testing of the PA subsystem alarm messaging to the SCADA system at each station, and provide troubleshooting and support for VTA to test alarm delivery to the YMF OCC.

3. Frequency response test from priority select circuit to speaker output at nominal Sound Pressure Levels for all inputs.

4. Demonstrate priority selection of local PA input using dual-mode telephone set.

5. Demonstrate feedback prevention feature for local announcements.

6. Demonstrate PA tone alert.

7. For dual platform-stations, demonstrate the ability to address individual platforms.

8. Demonstrate the ability of the PA system to make announcements with one of the two channels disabled per platform edge and all PA equipped light poles.

9. Demonstrate the ability to issue ad-hoc PA announcements via the new SCU.

10. Demonstrate the ability to issue scheduled PA announcements via the new SCU.

11. Functional tests of equipment for inputs at nominal Sound Pressure Level.

12. Functional test of local feedback, noise level sensing and automatic broadcast level compensation. The Contractor must test and record the gain using a sound level meter at each speaker location and each mid-point between speakers along the platform under normal operation.

13. Sound level tests for every line and handset input.

14. Correct phasing of all speakers.

15. Audio coverage test: every 3 m and 1.5 m (10 ft. and 5 ft.) from the platform edge [every 1.5 m (5 ft.) under a canopy] at 1.5 m (5 ft.) above the platform level; test frequencies using input from a pink noise generator at 250 Hz, 1 kHz, 3 kHz; Sound Pressure Level, dBA scale. Perform audio coverage test for the full length of each platform.

16. The Contractor must correct deficiencies, where necessary to optimize volume and uniformity of sound levels, and retest. The Contractor must schedule all tests with at least seven days advance notice to VTA.

B. PA and PIM Subsystems Integration Tests for ADA, NFPA 72, NFPA 130 compliance: None, will be completed by VTA.

3.03 FIELD QUALITY CONTROL

A. Quality: The quality of the Communications System installation must be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications and workmanship standards and practices.

B. Documentation: Refer to Section 6.6.2, Submittal, of the Special Conditions, for additional requirements to the contract documentation.

END OF SECTION

SECTION 27 42 20

PASSENGER INFORMATION MONITOR SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes the requirements of the Passenger Information Monitor (PIM) system at the two new LRT stations. The PIM system provides train destination information and emergency messages to passengers, employees, and emergency response personnel. Communications to the stations must be from the VTA Customer Service Center and the Operations Control Center (OCC) located in the Younger Maintenance Facility (YMF). Each station must also have the capability for announcements to a single station or groups of stations. Each center platform station must be capable of supporting PIM announcements specific to each platform edge of the center platform (Two separate messages).

1.02 RELATED SECTIONS

A. Section 6.6.2, Submittal, of the Special Conditions,

B. Section 01 07 23, Operation and Maintenance Data

C. Section 27 05 00, Common Work Results for Communications

D. Section 27 05 28, Pathways for Communications Systems

E. Section 27 11 16, Communications Cabinets, Racks, Frames and Enclosures

F. Section 27 11 19, Communications Terminal Blocks and Patch Panels

G. Section 27 13 00, Communications Network Cabling

H. Section 27 15 00, Communications Low-Voltage Conductors and Cables

I. Section 27 21 00, Communications Network Equipment

J. Section 27 26 00, Communications Programming and Integration Services

1.03 REFERENCED STANDARDS

A. The latest versions of the following standards and references apply to the work included in this Section, in addition to those codes and standards common to all communications subsystems specified in section 27 05 00 “Common Work Results for Communications”. If a conflict must arise between various standards, the California state code amendments must govern, or the most strict/conservative requirement must govern.

B. Americans With Disabilities Act (ADA).

C. Building Industry Consulting Services International (BICSI):

1. TDMM Telecommunications Distribution Methods Manual.

D. Federal Communications Commission (FCC).

E. National Fire Protection Association (NFPA):

1. 70 National Electrical Code (as amended by CEC).

2. 72 National Fire Alarm and Signaling Code.

3. 130 Standards for Fixed Guideway Transit and Passenger Rail Systems.

F. Underwriters Laboratories, Inc. (UL).

1. 48 Electric Signs.

G. California Building Code (CBC).

H. California Electrical Code (CEC).

I. Santa Clara County District Standards.

J. City of San Jose Standards

K. Local Billboard/Digital Sign Ordinances

1.04 SUBMITTALS

A. Preliminary Design Review: The Contractor must submit the following information as part of the PIM Preliminary Design Review submittal:

1. Preliminary design of any required network configuration and interfaces.

2. Description including catalog cuts of the equipment to be installed.

3. Preliminary design of the software configuration settings for the OCC workstations and Customer Service Center workstations for implementation of the PIM announcements at the 2 new stations.

4. Catalog of all display features of PIMs. Provide displays of text with a minimum number of 12 different fonts. Show sample displays with 100 mm (4 in.) high letters and 50 mm (2 in.) high letters.

5. Mechanical interface design of PIM and PIM sunshade and speaker to station elements.

6. PIM communication protocol. The communication protocol must include SNMP Agents and specific MIBs.

B. Cutover Plan: The Contractor must submit a Cutover Plan submittal package. Contractor must proceed with the equipment cutover only after approval of the Cutover Plan. The VTA will assign cutover dates and times for each station.

C. Final Design Review: The Contractor must submit a Final Design Review submittal package. The final design review package must include the final design of all components and interfaces of the system and must incorporate all comments made by the VTA during the Preliminary Design Review and Cutover plan submittals.

D. Installation Drawings: The Contractor must submit installation drawings. Contractor must proceed with the installation only after approval of the installation drawings.

E. Test Reports: Prior to the beginning of testing, the Contractor must submit the test plan and the test procedures for approval by the VTA. Each test procedure must clearly identify the time, test equipment, location, equipment/function tested and the pass/fail criteria. The Contractor must submit the results of the testing within 15 days after conclusion of the testing. In addition to the test signed by Contractor representatives, all tests must also be witnessed and signed off by VTA representatives. Test plan, procedures and reports shall be submitted for (see definitions in general testing requirements section TBD):

1. Factory Acceptance Tests

2. Field Installation Tests

3. Field Functional Tests

4. Systems Integration Tests (Per Station)

5. Systems Integration Tests (to OCC and River Oaks Customer Service Center)

F. As-built documentation: Within 6 weeks after the equipment and the functionality of the new system is verified and accepted by VTA, the Contractor must submit the as-built drawings and configuration as-built settings of the implemented system.

G. Operations and Maintenance Manuals as defined in Section 01 07 23, Operation and Maintenance Data.

1.05 QUALITY ASSURANCE

A. All components must be UL listed.

1.06 MEASUREMENT AND PAYMENT

A. Measurement: Communications Low-Voltage Conductors and Cables must be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Communications Low-Voltage Conductors and Cables must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in this Section complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Scope: The Contractor must design, furnish, install and test equipment and software upgrades for the Passenger Information Monitor (PIM) subsystem at 2 new LRT stations. The PIM system provides emergency messages to passengers, employees, and emergency response personnel, as well as customer service messages and advertising. Communications to the stations must be from the Operations Control Center (OCC) located in the Younger Maintenance Facility (YMF). Communications to the stations must be from the VTA Customer Service Center and the Operations Control Center (OCC) located in the Younger Maintenance Facility (YMF). Each dual platform station must be capable of supporting the future OCC-generated platform-specific PIM announcements.

2.02 DESIGN REQUIREMENTS

A. General

1. The contractor must implement all necessary changes required to the hardware and software at the head-end located at the VTA Younger Maintenance Facility (YMF) and VTA Customer Service Center and at the stations described below to provide for a fully functional PIM system. The contractor must ensure that there will be no loss of the existing system functionality.

2. The Contractor must design, furnish, install, and test equipment and software upgrades to PIM equipment at the following stations:

   a. Story

   b. Eastridge

3. The PIM equipment must include signs, network interface, PIM controller, sunshade, cabling, and all other equipment defined in these technical specifications and the Contract Drawings.

B. Passenger Information Monitor (PIM) design:

1. The PIM subsystem field devices must accept the PIM messages from the existing PIM servers and workstations located at the VTA River Oaks Customer Services. The existing PIM system currently directly addresses the digital PIM signs, via a network interface for each PIM Controller, through the PIM Controller, and then via digital video to the PIM signs, with a maximum of two PIM signs per PIM Controller. VTA must program the new PIM displays (and all other pertinent elements of the PIM display system) so that each new passenger station PIM will be controlled from VTA River Oaks, and the Contractor will implement the hardware and provide and test network elements necessary to reach the new EBRC passenger stations PIM signs. The contractor must utilize the IT WAN/LAN Network for the backbone communications between the VTA River Oaks and the field PIM Controller and PIM signs at passenger stations.

2. The PIM must provide for visual messages at stations. PIM message integration will be provided by VTA, which consists of a manual Standard Operating Procedure (SOP), to make coordinated equivalent PIM announcement as required by the NFPA 130 and ADA, whenever a scheduled or ad-hoc PA announcement is made from the OCC. The VTA Customer Service department creates and sends the equivalent PIM messages during normal business hours. The VTA Rail Operations at the YMF OCC also creates and sends the equivalent PIM messages before and after normal business hours. There is no system software level connection between the PIM subsystem and the PA subsystem.

3. Visual messages must be provided from existing VTA workstations, with existing software, configurated to accept the 2 new stations.

2.03 PIM EQUIPMENT

A. The PIM display must consist of a two hardened, back to back digital outdoor signs, and an associated controller for each sign or once controller for both signs mounted inside or between the digital outdoor signs, enclosed within a protective vandal proof hardened case.

1. The Digital Outdoor Sign combined with the Controller must have the following requirements:

   a. Size (each Digital Outdoor Sign): 43” nominal diagonal, approximately 39.50” x 23.28” x 4.89”

   b. Aspect Ratio: 16:9

c. Screen Adjustments: 4:3, Full, Zoom

d. Picture Mode: Standard, Dynamic, Personal, Theater

e. Picture Adjustments: Brightness, Contrast, Tint, Sharpness, Color

f. Color Depth: 16.7 Million Colors

g. Resolution: Full HD 1080p

h. TV Modes: NTSC, ATSC, MPEG4, QAM256, H.264

i. Weather Rating: IP68, fully sealed design

j. Operating Temperature: -31 degrees F to 140 degrees F

k. Brightness/Backlight Adjustment: Ambient light sensor, automatic adjustment of display brightness matching the lighting conditions.

l. Light Output: 2500 nits of light output

m. Operating Temperature: -31 degrees F to 140 degrees F

n. Vandal Resistance: Higher than an IK10 Rating

o. Glass Rating: Higher than IK10 Rated, Tempered and Anti-Reflective

p. Viewing Angle: 178 degrees

q. Response Time: 12 ms (Gray to Gray)

r. Refresh Rate: 60 Hz

s. Operating Time: 24 hours a day, 7 days per week

t. Maximum weight (one digital display) without additional enclosure: 88 lb.

u. Maximum weight of single Controller or dual Controller: 35 lb.

v. Color: Black

w. Connectors/Video Input: Coax 75 ohm, 15 pin D-Sub, HDMIx3, 480i, 480p, 720p, 1080i, 1080p

x. LAN Connection: RJ-45

y. Power: 12 VDC, provide power supply for 120 VAC/60 Hz operation.

z. Heat Sinks/Heat Transfer: Provide heat sinks/heat transfer components to maintain cooling of internal components under the specified conditions.

aa. Fiber optic break out box per section 27 13 00 Communications Network Cabling.

bb. Fiber optic interface and media converter per section 27 21 00 Communications Network Equipment serving the Controller(s).

cc. HDMI video cables and LFMC conduit as required from controller(s) to the two digital signs.

dd. The digital sign must be a Peerless-AV XHB432, or approved equal.

2. The Protective Vandal Proof Hardened Case or multiple Cases as required must have the following requirements:

   a. Designed and sized to house one or two Digital Outdoor Signs.

   b. Designed and sized to house the controller if controller is not within the Digital Outdoor Signs.

   c. Display Window: 3/8" minimum Lexan or other highly vandal resistant polycarbonate.

   d. Provides adjustable gap between Display Window and the Digital Outdoor Sign.

   e. Minimizes loss of display quality through the Display Window.

   f. Ventilated to provide environmental conditions within the limitations of the Digital Outdoor Sign, provide thermostat and blower within the case.

   g. Provide drainage holes for any moisture that condenses or migrates within the case.

   h. The case must be made of S316 stainless steel or painted aluminum, provided with a sunshade, and must be corrosion resistant. Paint color to be approved by VTA, but must be assumed initially to be non-painted stainless steel, or aluminum painted black, to determine thermal characteristics.

   i. The Display Window and Case must be able to withstand impact significantly beyond the IK10 rating, and remain in normal PIM operations as demonstrated by testing. The test must consist of the largest commercially available (within the boundaries of Santa Clara County) baseball bat or framing hammer, swung by an adult male test engineer weighing at least 275 lbs. (test engineer to be provided by VTA), impacting the Display Window and Case in a destructive test. This factory acceptance test to be conducted by the contractor and supported by VTA is a qualification test to be conducted on the first article for this project.

   j. It is anticipated that the enclosure must be a custom made enclosure, specific to the Digital Sign.

   k. The maximum weight of the Vandal Proof Hardened Case for a single Digital Outdoor Sign shall be 75 lbs. or 150 lbs. for dual Digital Outdoor Signs, excluding weight of the Digital Outdoor Signs.

   l. The Protective Vandal Proof Hardened Case must be the Armagard PDS-49-W-L-US-L, or LCD Enclosure Solutions "LCD Enclosure, Stainless Steel" sized for 43" Sign, or approved equal.

3. Total maximum weight of two Digital Outdoor Signs, Controller, and Vandal Proof Hardened Case or Cases, the entire assembly, shall be 365 lbs.

B. Location and Quantity: The Contractor must provide PIMs at all VTA EBRC Extension Stations at locations and in quantities shown on Contract Drawings. The new PIM interface must be compatible with the requirements of the existing proprietary PIM Controller head-end software.

C. PIM Addressing: Each PIM must be individually IP addressable from VTA River Oaks Customer Service, and YMF OCC.

D. PIM Readability: The light output of the PIMs must automatically adjust to ambient lighting conditions. The PIMs must be readable under standard station lighting and bright sunlight. PIMs must be equipped with sunshades to aid readability.

E. PIM Configuration: PIMs must be configured as double-sided signs, with the PIM Controller mounted between the signs.

F. The Contractor is allowed to propose a single enclosure to house both Digital Signs and PIM Controller, but must obtain VTA approval.

G. PIM Network Interface Card/Controller and Media Converter: A PIM Network Interface Controller (NIC) and Media Converter must be installed in the PIM.

H. The PIMs must communicate to OCC via the Station IT Access and IT Distribution LAN Switches. The physical interface to the Station LAN must be Ethernet 100/1000BASE-SX or LX as required by distance. The Contractor must provide a 100/1000BASE-SX or LX to 100/1000BASE-TX media converter to interface between the required multimode cable from the communications room to each PIM Controller, and required CAT 6 shielded cabling between the PIM Controller and the two PIM Digital Signs. The PIM Controller must provide two network interfaces for the PIM Digital Signs, plus a dual fiber uplink to the Station IT Switches.

I. PIM Protocol: The PIM protocol must be TCP/IP and must be compatible with IT Station LAN and PIM Controller. The PIM protocol must be fully compatible with the existing proprietary software installed at the River Oaks Customer Service.

1. The PIM must contain an SNMP agent necessary for the LAN Manager to perform all required performance monitoring and diagnostics. The agent must include all available Manufacturers MIBs, which report the operating state or allow the remote configuration of the PIM equipment.

J. PIM WAO: The PIM Fiber Breakout Box (FBB) must be installed in the PIM Controller and must conform to the following:

1. Provide for terminating 12 multimode fibers.

2. Equipped with 12 SC connector patch panel, fully populated and terminated.

K. PIM Cables: The PIM cables must be 6 fiber multi-mode OSP cables, and 2 fiber multi-mode jumper cables with SC or LC type connectors as suitable to interface with the PIM Controller. The 12 fiber multi-mode cables must connect the PIM Controller FBB to the Station IT LAN, and CAT 6 jumper cables must connect the PIM Controller to the two PIM NICs. All fibers must be terminated.

L. Miscellaneous Equipment: The Contractor must furnish and install miscellaneous equipment to complete the PIM subsystem. This must include surface conduit between station junction boxes and PIM equipment, and miscellaneous mounting hardware for PIM equipment.

PART 3 - EXECUTION

3.01 INSTALLATION

A. The contractor must implement the following at the stations:

1. General: The Contractor is to install, terminate, program and label the PIM equipment as shown on the Contract Drawings and as described below. The Contractor is to perform all necessary configuration of the PIM Subsystems to allow VTA operation of the PIM Subsystems. The Contractor is responsible for implementation of a fully functional PIM system.

2. Add, terminate and configure each station PIM and the associated equipment, provide troubleshooting and testing support to VTA for VTA programming of the Customer Service servers and workstations.

B. The contractor must implement the following at the VTA Customer Service Center and Younger Maintenance Facility (YMF) OCC: Configure the existing VTA workstations to providing PIM messages to the 2 new stations.

C. Provide, install and terminate proper grounding and protection equipment for all outdoor cabling entering the communication rooms or other enclosures. Provide proper grounding for the new equipment and wiring installed inside the communication rooms. Contractor is to submit grounding and protection equipment details for the approval by the VTA

3.02 TESTING

A. PIM Subsystem: The Contractor must perform the following tests:

1. Demonstration of test software and generation and display of visual messages.
2. Proper message delivery from the VTA Customer Service Center at River Oaks and Rail Operations YMF OCC to each Digital Sign, over the WAN/LAN connections configured by the Contractor.
3. Confirm IP addressing/mapping from River Oaks to each display, to make sure the correct sign is being addressed by the system for a specific message.
4. ADA compliance for text message size, for emergency messages.
5. Maximum viewing angle.
6. Verify automatic brightness adjustment under varying light conditions of night and day.

B. PA and PIM Subsystems Integration Tests for ADA, NFPA 72, NFPA 130 compliance: None, will be completed by VTA.

3.03 FIELD QUALITY CONTROL

A. Quality: The quality of the Communications System installation must be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications and workmanship standards and practices.

B. Documentation: Refer to Section 6.6.2, Submittal, of the Special Conditions, for additional requirements to the contract documentation.

END OF SECTION

SECTION 28 10 01

ACCESS CONTROL SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

This Section includes requirements for furnishing, installing and testing the Access Control System at stations and substation facilities. The Access Control system connects to the IT Station LAN switch for communications. The equipment and requirements for the system is as follows:

A. Access Control System at the:

1. EBRC Story Station including equipment rooms.
2. EBRC Eastridge Station including equipment rooms.
3. TES substation 33 and 34, both access doors into each of these substations.

B. Access Control Panel

C. Access Control Readers

D. Request-to-Exit Detectors

E. Key-In-Lever Cylindrical Locksets

F. Energy Transfer Hinges

G. Steel Door Contacts

H. Power Supplies

I. Associated Miscellaneous Equipment

1.02 REFERENCES

A. American National Standards Institute (ANSI):

1.	ANSI C2	National Electric Safety Code (NESC)
2.	ANSI/BHMA A156.29	Exit Locks, Exit Alarms, Alarms for Exit Devices

B. Americans with Disabilities Act (ADA)

C. California Code of Regulations (CCR):

1.	Title 24, Part 3	California Electrical Code

D. Electronics Industries Alliance (EIA)/Telecommunications Industry Association (TIA):

1.	TIA-232-F	Interface Between Terminal Equipment and Data Circuit Terminating Equipment
2.	EIA-310-E	Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange
3.	EIA/TIA-485	Standard for Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems
4.	TIA-568-C.0	Generic Telecommunications Cabling for Customer Premises
5.	TIA-568-C.1	Commercial Building Cabling Standard
6.	TIA-568-C.2	Balanced Twisted-Pair Telecommunications Cabling and Components Standard
7.	TIA-569-B	Commercial Building Standard for Telecommunications Pathways and Spaces
8.	ANSI/TIA/-606-B	Administration Standard for Commercial Telecommunications Infrastructure
9.	TIA 607-B	Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
10.	TIA 758-B	Customer Outside Plant (OSP) Telecommunications Infrastructure Standard

E. International Institute of Electrical and Electronic Engineers (IEEE):

1.	IEEE Std 299	IEEE Standard Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures

F. International Organization for Standardization/International Electrotechnical Commission (ISO/IEC):

1.	ISO/IEC 14443-2	Identification cards - Contactless integrated circuit(s) cards – Proximity cards – Part 2

G. National Fire Protection Association (NFPA):

1.	NFPA 262	Standard Method of Test for Fire and Smoke Characteristics of Wires and Cables

H. Underwriters Laboratories, Inc. (UL):

1.	UL 294	Access Control System Units
2.	UL 634	Connectors and Switches for Use with Burglar-Alarm Systems
3.	UL 1581	Standard for Safety Electrical Wires, Cables and Flexible Cords

1.03 SUBMITTALS

A. Product Data: Submit manufacturers' catalog cuts, specifications and other data required to demonstrate compliance with these Contract Specifications.

B. Shop Drawings: Submit Shop Drawings for panel layout, equipment mounting, and equipment interconnection diagrams.

C. Test Plan. Provide test plan with test procedure a minimum of 60 days prior to the approved date for commencement of testing. The test plan shall include testing the full functionality of the Access Control system for VTA review and approval.

D. Test Report. Provide test reports for VTA review and approval.

E. Operation and Maintenance Manuals. Provide the following submittals:

1. Operations manuals: Submit operating instructions outlining the step-by-step procedures required for system operation including description of each subsystem in its operating mode. Instructions shall include the manufacturer's name, service manual, parts list, and a brief description of the equipment, components, and their basic operating features.

2. Maintenance manuals: Submit maintenance instructions listing regular maintenance procedures, possible system failures, a troubleshooting guide for repairs, and simplified diagrams for the system as installed.

F. List of recommended spare parts. The VTA will determine the final list of Spare Parts to be delivered under this Contract.

1.04 QUALITY CONTROL

A. Products shall be manufactured by firms regularly engaged in manufacturing products indicated in this Contract Specifications Section.

1.05 SYSTEM DESCRIPTION

A. Access controlled doors include smart card readers, “request-to-exit” detectors, electrified locksets, energy transfer hinges and door contacts (to monitor intrusions) integrated into one system. Access controlled doors shall be hardwired to an access control panel located as indicated.

B. Access control panels shall be connected to the associated network access switches as indicated. Access control data must be transmitted to the VTA Administrative Facility as shown.

C. The access control system shall be configurable by an authenticated person via password protected access from any authorized networked workstation on the VTA network where the appropriate access control software is installed.

D. Access control cards will be issued and managed by VTA from a workstation on the VTA network.

1.06 MEASUREMENT AND PAYMENT

A. Measurement: Access Control System must be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Access Control System must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in this Section complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 ACCESS CONTROL PANEL

A. The Access Control Panel (ACP) shall be a complete modular system of components by a single manufacturer and have the following features:

1. Wall mount enclosure with conduit knockouts on top, bottom, right, left and rear sides.
2. Handle up to 4 entry doors.
3. 4-Hours Battery.
4. Anti-passback support – last area accessed, last reader accessed and time/date of last access.
5. Include fail-safe and fail-secure strike modes.
6. Activation and deactivation dates by card.
7. Report entire bit-stream with invalid facility code or invalid card format.
8. RS 485 serial communication to end devices and Ethernet to network point.
9. ACPs shall be compatible with existing VTA Access Control system software, equipment and devices.
10. ACPs shall be iSTAR Edge, iSTAR Pro, or equal.

B. Provide the user software and associated licenses necessary to operate the system.

C. Access Control Panel will need to be installed on a 5/8 inch Fire Rated Plywood, painted white with fire retardant paint.

2.02 ACCESS CONTROL READERS

A. Access Control Readers shall meet the following requirements:

1. Designed to mount and cover single gang boxes. Box covers and mounting must be suitable for outdoor use.

2. Pigtail panel connection.

3. Compatible with the VTA Access Cards.

4. Color shall be black.

5. Access Controls Readers shall be HID Corporation ThinLine II model 5395CG100, MiniProx model 5365EGP00, or equivalent reader for VTA HID Access Cards.

2.03 REQUEST-TO-EXIT (REX) DETECTORS

A. REX detectors shall sense motion in the room exit coverage area and signal the access control system and must meet the following requirements:

1. UL 294 compliant.

2. Include an externally visible activation LED.

3. Support single or double door use.

4. Wall or ceiling mountable.

5. Internal vertical pointability.

6. Wrap-around coverage pattern.

7. Selectable relay trigger mode.

8. Selectable fail safe/fail secure modes.

9. REX detectors shall be Bosch Model DS150i or equal.

2.04 KEY-IN-LEVER CYLINDRICAL LOCKSETS

A. Key-in-lever cylindrical locksets must meet the following requirements:

1. Comply with ANSI/BHMA A156.2, Series 4000, Grade 1 for key-in-lever locksets.

2. UL-listed (3 hour A Label).

3. Be equipped with electrified, fail-secure mechanism rated at 24 Vdc, 0.18 amps continuous duty.

4. When the outside lever is locked, the lever shall move freely without operating the latch bolt.

5. Lever trim must have individual heavy-duty springs behind the rose for lever return and to prevent lever sag. Trim must be through-bolted with two 10-32 screws coated with thread sealant to provide strength and resistance to loosening. Inner and outer trim must "bottom out" to prevent door collapse. Roses must be a minimum of 3-1/2-inch diameter.

6. Levers must be solid and meet the Federal ADA and State disability requirements. Inside levers must be attached by an Allen-head set screw to prevent tampering or vandalism.

7. Locksets must adjust to fit door thickness from 1-3/4-inch to 2-1/4-inch.

8. Locksets must be non-handed and not require field disassembly for re-handing; preparation for the door shall be non-handed.

9. Finish, lever, and trim coordinated for each door with architectural door hardware schedule

10. Key-in-lever cylindrical locksets must be Schlage or equal.

2.05 ENERGY TRANSFER HINGES

A. Each access controlled door with an electrified lockset must be equipped with one energy transfer hinge to enable the transfer of low voltage power from the hinge jamb to the electrified lock. Energy transfer hinges must meet the following requirements:

1. Center located wire access holes.

2. UL-F listed.

3. Non-conductive wire access cap.

4. Finish coordinated for each door with architectural door hardware schedule.

5. Energy transfer hinges shall be Command Access Model ETH2W or equal.

2.06 STEEL DOOR CONTACTS

A. Steel door contacts must meet the following requirements:

1. UL 634 listed.

2. Contain a hermetically-sealed magnetic reed switch.

3. Contact and magnet housing must snap-lock into a 1-inch diameter hole.

4. Housings must be molded from flame-retardant ABS plastic.

5. Steel door contacts must be GE Interlogix® 2707A-L Series Steel Door contacts or equal.

2.07 POWER SUPPLIES

A. Power supply must meet the following requirements:

1. UL 603 and UL294 compliant.
2. Cabinet LEDs indicate battery voltage and AC fault.
3. Low battery warning.
4. AC failure supervision.
5. Single or dual battery configurations.
6. Up to ten hours backup time with dual batteries.
7. Reverse polarity protection.
8. Overcurrent protection.
9. Thermal protection.
10. Batteries.
    a. Dual Rating 12V/ 34Ah.
    b. Battery Backup Time must be ten hours at full load using two 17Ah SLA batteries.
    b. Battery Recharge Time must be 12 hours maximum.
11. Cabinet Physical Dimensions (H x W x D, 16.25 x 14.5 x 4.0 inch)
    a. Housing 16 gauge carbon steel
    b. Operating Temperature 32 degrees to 122 degrees F
12. Heat Dissipation 597 BTU per hour
13. Power supply/cabinet must be Advance Power System (APS) model AS0063-00 or equal.

2.08 MISCELLANEOUS EQUIPMENT

A. Provide end of line resistors, diodes, DIN rail, terminal blocks and other miscellaneous equipment to create a fully functioning access control system.

PART 3 - EXECUTION

3.01 INSTALLATION

A. ACPs and wiring for door access control equipment and door contacts must be provided for stations and TES substations as shown.

B. Cables between each controlled door and the associated Access Control Panel must be routed without any splices.

C. Contractor must travel to TES TPSS unit substation manufacturing site, and install the Access Control System in the unit substation as it is being manufactured. Contractor must complete the installation and be onsite at the manufacturing facility during installation and testing of the system.

3.02 TESTING

A. Field Tests: Field tests must be conducted in three phases following the installation of all field devices, ACP, and interconnecting wires and cables as follows:

1. Phase 1 – Installation Verification: Verify installed equipment for proper installation per manufacturer's specifications. Each piece of equipment must be tested using element device specific test procedures. Verify the continuity and correct termination of all cabling using Contractor-prepared interconnection diagrams.

2. Phase 2 – Functional Testing: Each access-controlled door function must be verified by entering and exiting each door to verify that the door status is correctly displayed at the main access control panel.

3. Phase 3 – End-to-end Testing: Verify that all access control system alarms and indications are correctly transmitted to VTA Operations Control Center. This test must include testing access with authorized and un-authorized VTA IDs, as well as doors held open and forced open.

3.03 TRAINING

A. Maintenance Training must include the following:

1. Instructions and "hands-on" demonstration of the operation of all system components and the entire system including program changes and functions

2. Operation of diagnostics and self-test routines

3. Cleaning, remote and locate status measurements, replacing consumable / replaceable parts.

4. Equipment and test procedures

5. Badging

6. Hardware configuration

7. Database Configuration

8. Monitoring

9. Reporting

10. Administration

B. Operations Training must include the following:

1. Configuration, usage, sensitivity adjustments, and similar
2. Badging, flashing authentication items
3. Monitoring
4. Administration
5. Reporting

END OF SECTION 28 10 01

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SECTION 28 20 00

VIDEO SURVEILLANCE (CCTV)

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes requirements for the fully functional and complete CCTV system to be designed, furnished, installed, integrated with the existing CCTV system, and tested by the Contractor. Furnish all labor, materials, equipment, software and programming; and performing all testing for operation readiness related to the installation of CCTV systems at the facilities shown on the plans. The system must monitor and record video from the areas as indicated on the plans. The system equipment must be Internet Protocol (IP) network based. Major elements of the CCTV equipment include, but are not limited to:

1. Fixed Cameras

2. Optical Pan-Tilt-Zoom Cameras

3. Digital Pan-Tilt-Zoom Cameras

4. Infrared IDS Sensor Pan-Tilt-Zoom Cameras

5. Digital Video Recorders

6. Camera Accessories (including mounts, housings, cabling, power supplies)

7. CCTV Software DVR and Camera Licenses

8. Modifications to existing Client/Server CCTV software, including configuration changes to add new cameras and required functionality.

B. This Contract must provide the design, procurement, installation and testing of IP cameras, camera power supplies, cabling, connectors, network switches, digital video recorders (DVRs), and software provisioning to integrate the EBRC Capitol Rail Stations, guideway and TPSS cameras into VTAs existing video management system.

C. CCTV Cameras must be provided for each new station, at TPSS, and in two of the four Intrusion Detection areas on the guideway, as shown on the Contract drawings (see Section 28 31 00, “Intrusion Detection System (IDS)” for IDS details).

D. The Closed Circuit Television System to be designed, procured and installed by this Contract is intended to be integrated into the existing LRT and CCTV system to provide the following functions at new EBRC Capitol Rail Stations, and along the new Guideway/Trackway:

1. Use of IP Fixed and IP PTZ Cameras for general surveillance coverage of station platforms, grade crossings, pedestrian bridges, all gated pedestrian crossings, stairways, elevators.

2. Use of IP Fixed Infrared Cameras at IDS locations with video analytics as intrusion detection sensors for persons, animals and other objects, and providing alarms to the SCADA system via contact outputs.

3. Use of IP 180 Degree High Resolution Cameras with video analytics at Station Platforms with video analytics to detect intrusion into the LRT trackway from passengers or others at stations.

4. Intrusion detection at other areas not open to the public.

5. Monitoring of emergency responses.

6. Real time viewing and video recording of all camera images for incident review and evidence cataloging.

E. The video data from the CCTV Cameras must be recorded at the Contractor provided station Digital Video Recorders (DVRs). The Contractor must also provide and install all necessary enclosures, CCTV LAN/WAN Network Equipment and cabling as shown in the Contract documents, to provide a complete and fully functional CCTV system.

F. The CCTV equipment must be Internet Protocol (IP) network based. All CCTV cameras must be IP cameras. The CCTV Cameras must interface with station DVRs and the existing VTA server/clients at VTA Protective Services, VTA Rail Operations and the VTA Administrative facility via the ethernet Communications Transmission System and Communications Network Equipment.

G. The new CCTV Camera Equipment must be fully compatible with the existing VTA CCTV systems, VTA CCTV software applications, support all existing VTA CCTV System functionality, and must facilitate seamless integration into the existing VTA CCTV System. The Contractor must implement all necessary configuration and software changes to the ethernet network and the existing CCTV equipment to provide for a fully functional and integrated CCTV system. The manner in which new hardware and software is programmed and operated, must be the same as the existing CCTV equipment.

1.02 RELATED SECTIONS

A. Section 6.6.2, Submittal, of the Special Conditions,

B. Section 27 05 00, Common Work Results for Communications

C. Section 27 05 28, Pathways for Communications Systems

D. Section 27 11 16, Communications Cabinets, Racks, Frames and Enclosures

E. Section 27 11 19, Communications Terminal Blocks and Patch Panels

F. Section 27 13 00, Communications Network Cabling

G. Section 27 15 00, Communications Low-Voltage Conductors and Cables

H. Section 27 21 00, Communications Network Equipment

I. Section 27 26 00, Communications Programming and Integration Services

J. Section 28 31 00, Intrusion Detection System (IDS)

K. Section 28 40 00, SCADA Monitoring and Control System

L. Section 34 54 00, Automated Fare Collection System

1.03 REFERENCED STANDARDS

A. The latest versions of the following standards and references apply to the work included in this Section, in addition to those codes and standards common to all communications subsystems specified in section 27 05 00, Common Work Results for Communications. If a conflict must arise between various standards, the California state code amendments must govern, or the most strict/conservative requirement must govern.

B. International Electrotechnical Commission (IEC)

1. IEC standard 60529, International Protection Ratings

a. IP42 Index of protection against solids, liquids, and impact.

b. IP54 Index of protection against solids and liquids corresponding to dust protection with dust allowed to deposit but not to affect operations and protection against splashing water.

c. IP66 Index of protection against solids and liquids corresponding to a dust proof enclosure; a protection against high-pressure jets of water.

d. IP67 Index of protection against solids and liquids corresponding to a dust proof enclosure; a protection against immersion in water up to 1 meter of depth.

2. IEC standard 62262, Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts, IK10 rating.

3. ISO/IEC 14496-2 Information Technology - Coding of Audio-Visual Objects - Part 2: Visual

C. Insulated Cable Engineer’s Association (ICEA)

D. American Public Transportation Association (APTA)

E. Motion Pictures Experts Group (MPEG)

F. Internet Engineering Task Force (IETF)

G. International Protection or Ingress Protection (IP) rating

H. Underwriter's Laboratories, Inc. (UL)

1. UL 2044 Standard for Commercial Closed Circuit Television Equipment

2. UL 2391 Equipment with Remote Feeding Telecommunication Circuits Intended for Backwards Compatibility in Legacy Telecommunication Equipment

3. UL 3044 Standard for Surveillance Closed Circuit Television Equipment

1.04 QUALITY ASSURANCE

A. Software Quality Assurance: The Contractor must plan, implement, administer, and maintain a comprehensive software and hardware quality assurance program, conforming to the IEEE-730 standard.

B. Emissions: All CCTV Camera Equipment, DVRs, and any other active devices must comply with FCC emissions regulations for such devices.

C. Past Performance and Experience: The Contractor must demonstrate that staff assigned to this project have previous successful experience installing CCTV equipment and software, with a minimum of 5 years of experience in furnishing and installing a system of comparable size and complexity. Submit references for similar projects completed within the last three years. As a minimum provide project name and address, client name and telephone number. Provide a brief description of each project indicating types of systems installed. Obtain approval from VTA for staff assigned to this Project, prior to proceeding with the work of this section.

D. Contractor must ensure that products are manufactured by firms regularly engaged in manufacturing products described in this Contract Specifications Section.

E. CCTV System Management Database: A CCTV System management database must be developed and provided to the VTA. The database must define all applicable CCTV optical, mechanical, electrical, firmware, software and network configuration settings for each camera, LAN/WAN switch, DVR and other CCTV System associated equipment. The database must be verified during installation and test, and must be provided to the VTA in electronic digital format and hardcopy format. Electronic digital data must be either flat files, or database files of a commercially available relational database product which operates in the Windows operating system environment with version number to be agreed between the VTA and the Contractor.

F. Inspection: VTA reserves the right to make inspection and tests as necessary to determine if the CCTV System installation meets the requirements of these technical specifications. VTA reserves the right to reject any part or all of the installation that is defective in any respect. VTA reserves the right to request additional tests to provide further satisfaction that the CCTV System has been installed in accordance with the requirements of these technical specifications at no additional cost to the Contract.

1.05 SUBMITTALS

A. Submittals must be in conformance with:

1. Section 6.6.2, Submittal, of the Special Conditions, except as modified herein. If there is a conflict between the requirements of this Section and Section 6.6.2, the requirements of this Section must govern.

2. Special Conditions – SC-6, Contract Data Requirements, SC-51, Technical Submittals List.

3. General Conditions – GC-41, Product Substitutions, GC-43, Submittals of Shop Drawings.

B. Design Information:

1. Preliminary Design Review:

a. Items required to be submitted by the Contractor for Approval as part of the preliminary design include, but are not limited to, the following:

1) The Contractor must interface with the Resident Engineer and Security Department to determine the function of each camera to be installed on the system. Each camera's function must be categorized as either to detect, monitor, identify or recognize the target. Based on the function of the camera, the Contractor must determine the percent of the screen to be occupied by the target. This percentage must be the below based on the function of the camera:

a) Detect – Not less than 8 pixels per foot of the screen occupied by the target.

b) Monitor – Not less than 20 pixels per foot of the screen occupied by the target.

c) Identify – Not less than 40 pixels per foot of the screen occupied by the target.

d) Recognize – Not less than 80 pixels per foot of the screen occupied by the target.

e) The Contractor must capture this camera target information in a table that lists the camera location, target, function, field of view, and resolution requirement.

f) Once the Resident Engineer and Security Department comments have been addressed and the location, field of view, and lens setting for each of the cameras have been established, it must not be revised without a submittal and Approval of the Resident Engineer.

2) Signal and power distance calculations to accommodate for voltage drop, ethernet distance limitations for each piece equipment must be provided, including but not limited to CCTV cameras, ethernet switches, camera power supplies and related equipment.

3) Systems design presented, with a description of the CCTV System configuration, detailed functional block diagrams, electrical/electronic signal flow and power diagrams.

4) Provide full performance specifications.

5) List of all electrical, mechanical and CCTV material, equipment and including CCTV cameras, CCTV video transmitting/receiving equipment, storage/recording equipment compatible with VTA's existing network, converters, fiber distribution panels, power supplies, conductors, cables, patch cords, junction boxes, pull boxes, and other accessories as required to be used on the CCTV project

6) Manufacture's literature and drawings for each item listed, including technical parameters and interfaces, identifying the manufacture's method of installation.

7) Configurations for stations and for Intrusion Detection areas.

8) List of proposed lenses for all camera installations.

9) Calculations of coverage showing areas to be covered by each camera.

10) Calculation for video processing and storage capability.

11) Locations and mounting of all cameras, IDF/Midspan Junction Boxes, and Surveillance poles.

12) Text describing each element of the CCTV system.

13) Drawings, including detailed block and lower level diagrams, intended to show each typical configuration, including integration into the existing CCTV System.

14) Identification and specification of all internal module-to-module data communications interfaces and all electrical interfaces.

15) CCTV System equipment data sheets and performance specifications for proposed equipment, identified by manufacturer and model number with all options.

16) CCTV System equipment performance analysis using manufacturer data. Note that this analysis must consider the CCTV System bandwidth requirements in conjunction with bandwidth requirements of other subsystem's elements located on the same physical network.

17) CCTV System equipment reliability analysis including the MTBF for typical station CCTV Camera, DVR and LAN/WAN equipment.

18) Maintainability: Cameras must be mounted in locations that are accessible for maintenance personnel with only a 12 ft. step ladder. The CCTV equipment must be designed, configured, and installed to address the safety of maintenance personnel.

19) Preliminary version of the CCTV System Management Database. This version must include a list of settings for each element comprising the CCTV System.

2. Final Design Review Submittal: The Contractor must submit the following information:

a. Final description of the CCTV DVR software and modifications to the existing VTA CCTV server/client software and the final version of the CCTV System Management Database.

b. Installation Plans:

1) Station and yard facility CCTV equipment layout drawings, showing the location of each camera and piece of equipment.

2) Arrangement of equipment in cabinets/racks.

3) Cabinets/racks mounting details.

4) Inter-cabinet/rack cable plan.

5) Wiring tables – Cabinets to field equipment.

6) Plans demonstrating the unobstructed field of view of each camera.

c. Detail drawings showing final configuration, including location, type and termination of intra-cabinet and inter-cabinet cables.

d. As part of the Hardware Final Design Review submittal: Detailed installation plans, cable drawings, schematics, equipment, arrangement of equipment in cabinets/racks, mounting details, cable plans within and between cabinets/enclosures/facilities and to field equipment/cameras, I/O wiring diagrams including termination for each type of location (e.g. station, Intrusion Detection area, etc.) where the CCTV equipment is located.

e. Values for all configurable settings.

f. List of all lowest level replaceable units, each with MTBF.

g. Shop drawings with bill of materials for all locations, all equipment.

h. Table showing each camera, manufacturer, model, primary target, purpose and settings.

i. Manufacturer's Instructions: Where installation procedures, or any part thereof, are required to be in accordance with the recommendations of the manufacturer of the equipment being installed, submit printed copies of these recommendations prior to installation.

j. Test plan in accordance with the contract documents.

k. Camera naming.

l. On screen camera identification, date, time.

m. CCTV camera call-up & recording features and schedule (including video activity detection).

n. CCTV camera recording schedule including video motion detection area definition.

o. Alarm configuration, input and outputs for each camera.

C. Testing Documentation: As part of the Communications System As-built documentation, include:

1. Prior to the CCTV equipment testing, the Contractor must submit test procedures for approval by the VTA. As a minimum, the test procedures must meet the testing requirements found in Section 3 below, must demonstrate full functionality of the CCTV system, and demonstrate specification compliance. Include test data sheets, to be filled out during testing and witnessed by VTA.

2. Test reports including test plan, how the particular test fits into the test plan, VTA approved test procedures, and VTA witnessed test data sheets.

D. As-Built Documentation: As part of the Communications System As-built documentation, include:

1. For each location, drawings of all CCTV System equipment elements as located on poles, on structures, in cabinets, power cabling, data communications cabling to the LAN/WAN.

2. CCTV DVR software and modifications to the existing VTA CCTV server/client software.

3. Contractor must provide VTA with a flash drive with all CCTV equipment software program files used for initial calibration, configuration and testing system connections to the existing VTA network.

4. All witnessed (and signed by VTA) test data sheets as part of test procedures, included with test reports.

5. The CCTV System Management Database, including complete instructions on using and maintaining the database.

6. Values for all configurable settings.

7. List of all lowest level replaceable units, each with MTBF.

8. List of recommended spare parts.

9. Bill of materials.

10. Table showing each camera, manufacturer, model, target, purpose and settings.

11. Operations and Maintenance Manuals

E. Training Courseware

1.06 MEASUREMENT AND PAYMENT

A. Measurement: Video Surveillance must be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Video Surveillance must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in this Section complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION

A. General:

1. Furnish and install new IP based PTZ and Fixed type CCTV cameras as shown on the plans including all mounts, power supplies, conduits, connectors, and cables and all other necessary hardware, application software, and programming for a fully functional CCTV system. The manner in which new cameras are programmed and operated must be the same as the existing CCTV equipment.

2. The Contractor must provide the most current manufacturer model numbers for CCTV equipment at the time the Contractor procures the equipment, and must not provide out of date equipment, even if it is specified below. Contractor shall provide equal or better equipment and functionality than that specified as approved by VTA. All equipment provided by the Contractor shall be in current production by the manufacturer.

3. The Contractor is responsible to ensure equipment compatibility, functionality and to provide additional interfacing equipment, mechanical, electrical and CCTV related hardware, software whether or not listed below, to achieve a fully functioning Internet Protocol (IP) network based CCTV system.

4. Contractor must provide CCTV network cameras, boxes, equipment and other accessories, including Internet Protocol (IP) based Fixed and Pan Tilt Zoom (PTZ) type cameras, video routing and recording/storage equipment along with media interface equipment and mounting accessories. Contractor is responsible to furnish and install correct type of mounts, brackets, power supplies, media types/interfaces for each type of CCTV camera, recording and network storage equipment.

5. All new CCTV equipment, software and programming must be compatible with the existing VTA CCTV systems. The manner in which new hardware and software is programmed and operated must be similar to the existing VTA CCTV System.

6. The CCTV System must use open standard based interfaces and software.

7. CCTV equipment providing the same functions must be uniform and have the same type and model supplied by a single manufacturer.

8. The Contractor must provide a complete and fully functional enterprise-class, IP-based, networkable CCTV system for EBRC Capitol Stations, Guideway and Facilities that meets the requirements of this Section. All equipment must be of solid-state design and construction. All software, equipment and materials must be new and must be the latest version or model in use at the start of construction. Equipment and materials must be the best of their respective kinds; they must be free of corrosion, scratches and other such defects.

9. The Contractor must coordinate the design of the CCTV system with the lighting, architectural and landscaping design to ensure that location and lens, and camera types are appropriate for the application.

10. Experience of Contractor Personnel: Contractor technicians installing and configuring the DVRs, security video management software or the workstations must be certified to perform that function by the CCTV software supplier and must have previously installed and configured CCTV systems of similar or more complexity on at least three previous projects. Such certification must be provided to the Engineer.

B. Functional Requirements

1. General:

   a. VTA Protective Services must have primary control of the CCTV cameras through the exacqVision VMS software.

   b. Digital/networked video recorders, cameras, power supplies, IP switches, and software must be compatible with and incorporated into VTA's existing CCTV video management system, including the latest VTA version of the CCTV software available at the start of construction.

2. Mounting and Installation

   a. The Contractor must furnish, install, terminate and configure all CCTV equipment specified under this project; as shown on the Contractual drawings; and to make a complete fully functional system.

   b. Utilize tamper-resistant type fasteners for installation of all cameras, camera mounts, Camera enclosures, and associated junction boxes and other enclosures serving the CCTV System.

   c. If necessary, the contractor must furnish and install miscellaneous wiring, mounting and CCTV System components not specifically outlined by these specifications to provide for a complete functional CCTV system fully compatible with the existing VTA CCTV System.

   d. Provide all necessary accessories, devices, wires, cables and conduits for proper interconnection of the equipment specified herein to provide a completely integrated and operational CCTV System.

   e. CCTV equipment in communications rooms must be designed for mounting in standard 19-inch rack per EIA 310-E.

   f. Furnish, install, configure and test accessories such as mounts, connectors, modules, cards, converters, cable assemblies, etc. as required for outdoor mounting, power, alarm controls and indications, and video output via an Ethernet cable. See contract drawings for location and field application details.

   g. Wall and Ceiling Mounts: The camera mount units must be designed to support loads of up to 125 pounds at an angle of 90 degrees perpendicular to a surface. Equip each mount assembly with an adjustable head adapter for 360 degree horizontal and plus/minus 90 degree vertical plane adjustment.

   h. All parts and equipment must be provided and installed to resist the corrosion environment at VTA for a period of 15 years.

   i. Meet UL/FCC/CE/CSA/NEMA Safety Certifications, ratings and standards for weatherproof, outdoor applications.

   j. Field of view of cameras monitoring doorways for equipment rooms must be mounted to ensure clear identification of anyone entering the building.

k. Locate cameras so that their field of view (FOV) is not restricted. Plans demonstrating the unobstructed FOV of each camera must be submitted for VTA review.

l. Locate cameras so that they never directly view the sun. The field of view of cameras must be adequately illuminated either by natural light or by luminaries. Within the field of view, particular care must be taken to avoid extremes of light and shadow.

m. Power cameras installed by contractor through POE with the use of mid-span power injectors when necessary. Other cameras must be powered through POE or through the use of power supplies compatible with the voltage and current rating of each camera. Total power consumption of cameras and other devices powered from POE on switches must not exceed the maximum POE rating of the switch minus 25percent.

n. All grounding must be in accordance with EIA, National Electric Code, local standards, and these Contract Documents. Each piece of equipment must be grounded in accordance with the recommendations of the manufacturer. All signal grounding must be isolated from electrical protective ground except at a single common point.

3. Network Requirements

a. The Contractor must provide a separate virtual local area network (VLAN) on the IP network for video transport between field equipment and to the VTA Protective Services Department, VTA Administrative Facilities, and the Rail Operations Center. The VLAN must be configured to bandwidth limit the total transport of all video on the network to 50 cameras back to these facilities. The configuration must allow the security technicians to view any 50 cameras on the existing LRT and the EBRC/Capitol Rail Line Station network simultaneously.

b. A separate VLAN, meeting the same network requirements as item 3a above must be provided for the Fixed infrared cameras IDS sensors.

4. Software Programming and System Configuration

a. All new CCTV equipment, software and programming must be compatible with the existing VTA CCTV systems. The manner in which new hardware and software is programmed and operated, must be the same as the existing CCTV equipment.

b. The VTA Operations Control Center, VTA Protective Services and IT Administrative Department must have access to view and control video from the CCTV network. The video management at these locations is currently comprised of the following:

1) exacqVision VMS software, Enterprise Server Option, EVES-0l

2) exacqVision VMS software, IP camera licenses, EVIP-0l

3) HP ProLiant ML350p Gen8 Video Server.

c. The most current CCTV software must be configured so that if any EBRC Capitol Rail Line Station wayside DVR fails it will alarm and video that was being recorded by the failed DVR will default to being recorded by the existing DVRs at VTA Protective Services.

d. Video must be configurable between MJPEG and H.264 format.

e. Video must be stored at a selectable rate of 5, 10, 15, and 30 frames per second in a local storage device in the communications equipment rooms as described below.

f. Frame rates of 5, 10, 15, and 30 frames per second for live video must be available for VTA personnel to select the frame rate for the stream they are viewing.

g. Frame Rate: All cameras except infrared sensors must support frame rates adjustable from 5 to 30 frames per second. The frame rate must be remotely programmable over the network.

h. A minimum of 16 live or stored video streams must be viewable on one single screen at any one time, concurrently at VTA Protective Services, VTA Rail Operations Control Center, and at the VTA Administrative facility, for a total of 48 live or stored video streams.

i. Camera settings and configuration must be remotely accessible.

j. The recording and viewing frame rates must be independently configurable for each camera for up to 30 frames per second. The recording frame rate must be configurable per time of day and day of the week.

k. The CCTV system must allow for simultaneous viewing and recording.

l. The CCTV system must allow for multicasting.

m. The CCTV system must provide the capability to remotely restrict viewing and/or controlling of a camera or group of cameras.

n. The CCTV system must provide the capability to prioritize access to control of cameras based on access level. This prioritization must be remotely configurable.

o. Furnish and install software for the CCTV system and the software use license for each new CCTV camera being supplied. The manner, in which new cameras are programmed and operated, must be the same as the existing CCTV equipment.

p. All licenses necessary for the operation of the CCTV system must be provided, including but not limited to exacqVision VMS software, enterprise server option, EVES-01 or approved equal; and exacqVision VMS software IP camera licenses, EVIP-03 or approved equal.

q. Provide software licenses necessary for the operation of the Fixed infrared cameras IDS sensors, preferably using the same software as for other cameras. Provide infrared camera software for DVRs, cameras and workstations.

5. Video Monitoring, Control, and Storage

a. VTA Protective Services must have primary control of the CCTV cameras through the existing exacqVision VMS software installed at VTA Protective Services. Secondary Control must be provided at both the VTA Rail Operations Control Center, and at the VTA Administrative facility. Provide all necessary licenses and upgrade CCTV systems software at all three facilities, and as required to add the cameras to the existing system.

b. Provide a local DVR server and video storage in the communications equipment room compatible with the existing exacqVision VMS software, Enterprise Server Option, EVES-0l and the existing HP ProLiant ML350p Gen8 Video Server. The local storage must be sized to store images from all cameras connected for 14 days at 4CIF at 30 frames per second plus 25 percent.

c. The origin of images must be unique only to the given camera so that if the images have been tampered with, they can be traced back to the point of origin.

d. Alarm Buffer: A pre-alarm buffer must be provided on each camera to allow for up to five minutes of video to be captured prior to the alarm event.

6. Video Analytics

a. General: The Contractor must configure the Video Management Software, within the limits of that software, to provide video analytics for intrusion detection, object left behind and loitering detection, within stations and at IDS locations, to recognize potential security threats, and allow for a timely and appropriate response.

b. Intrusion Detection must be implemented as further described in these specifications, for LRT trackway near stations and near IDS locations, to determine when unauthorized persons, animals or objects have entered a prohibited zone, and track their movement from one zone to another, triggering increased recording quality and alarms.

2.02 FIXED CAMERAS – STATIONS, TRACKWAY, SIGNALS, TPSS

A. The fixed camera dome system must be a discreet, miniature camera dome system with day/night auto switching color/black-white, IP video camera, remotely adjustable pan-tilt-zoom lens with optical and digital zoom and auto focus; low-light, Power-over-Ethernet (IEEE 802.3af or 802.3at), compatible with the VTA adopted CCTV client/server/recorder software and rated for outdoor use. It must include an enclosure consisting of a back box, lower dome, and mounting. The camera must be suitable for outdoor locations, with a 100BaseT Ethernet RJ45 port. Multiple types of mounting equipment must be required, for various mounting requirements. The camera should have the following features as a minimum:

B. Lenses must be designed to provide desired coverage at each site as approved by the VTA. Cameras must incorporate automatic backlight compensation, automatic gain control, both internal and external synchronization, electronic shutter, and digital signal processing.

C. The fixed camera dome system for stations, station platforms and other locations must be an Axis P3375-VE fixed dome network camera or approved equal, including Axis P33-VE, network cameras pendant kit with weathershield or approved equal. The camera must meet or exceed the following specifications:

1. Optical Lens - Varifocal 3-10 mm lens, Horizontal field of view: 90°–34°, Vertical field of view: 50°–20°, Remote focus and zoom, P-Iris control, IR corrected

2. Optical Zoom – 3.3 X

3. Digital Zoom – Digital PTZ, preset positions

4. Power - Power over Ethernet (POE) compatible and compliant to IEEE 802.3af or 802.3at

5. Network – 100BASE-TX, POE, RJ-45 connector

6. Mechanism - Remote focus and zoom, P-Iris control, IR corrected

7. Image sensor - 1/3-inch RGB CMOS

8. Scanning Mode - Progressive Scan

9. Maximum Resolution – 1920 x 1080 (1080p)

10. True Day/Night Capability, automatically removable infrared-cut filter

11. Black and white mode operation - automatically switches from color mode to black and white mode in low illumination

12. Video Compression – motion JPEG (MJPEG) and H.264 (Baseline and High Profile-MPEG 4 part 10/AVC)

13. Multiple, individually configurable streams in H.264 (high profile) and Motion JPEG

14. Maximum Frame Rate - 60fps

15. The camera must have a weatherproof outdoor enclosure and mounts, must be IK10 vandal resistant with an IP66 and NEMA 4X rating

16. Capable of operating within the temperature range of -40 (minus 40) degree F to 131 degrees F

17. Humidity – 10-100% condensing

18. Built in blower and/or heater adequate for required temperature range and humidity levels

19. Minimum Illumination - 0.15 LUX color, 0.03 LUX (B/W) at F1.4

20. ONVIF compliant

21. Dome – clear

22. Audio – One-Way or Two-Way streaming

23. Audio Input/Output – External Microphone input or line input, line output, all 3.5 mm

24. SCADA interface – One supervised alarm input, and one digital output

25. Security – Password protection, IP address filtering, HTTPS encryption, IEEE 802.1X network access control, centralized certificate management.

2.03 FIXED 180 DEGREE CAMERA DOME SYSTEM

A. Fixed 180 degreed CCTV camera, capable of detecting persons, animals or objects entering the light rail trackway, at station locations, must be provided. Two camera housing units each unit with four cameras each, must be mounted to the PIM signage pole at the end of the crossarm, and must provide 360 degree coverage of both light rail trackways at each passenger station, on both sides of the station. These cameras must use video analytics to determine intrusion, while recognizing that trains are not to be alarmed. The SCADA Alarm at central control must advise LRT OCC Console operators, to contact trains in the area and advise LRT train operators to slow down near stations and stop should an obstacle be on the trackway.

B. The Fixed 180 Degree Camera Dome System for station platforms must be a four sensor (camera) system, combined into a single camera, with seamless stitching of all four images. It must have day/night auto switching color/black-white, IP video camera, with optical and digital zoom and auto focus; low-light, Power-over-Ethernet (IEEE 802.3af or 802.3at), compatible with the VTA adopted CCTV client/server/recorder software and rated for outdoor use, with a 100BaseT Ethernet RJ45 port. Multiple types of mounting equipment must be required, for various mounting requirements.

C. Camera video analytics must be configured by the Contractor, for detection of persons, animals or objects, within the trackway bounded by the yellow platform edge, then transversely across the trackway, to the barrier consisting of the concrete guideway parapet or fence; and then longitudinally as far as the camera view will allow. The system must distinguish between trains versus persons or objects, and only alarm when persons or objects enter this defined area. These alarms must be reported via contact closure output from the camera, the SCADA system remote I/O unit within the IDF.

D. The Digital Only PTZ Camera Dome System must be an Axis P3807-PVE, including mounting kits and accessories, or approved equal. The camera must meet or exceed the following specifications:

1. Optical Lens – Fixed 3.2 mm, F2.0 lens, Horizontal field of view: 180°, Vertical field of view: 90°
2. Camera Angle Adjustment – Pan +/- 180°, Tilt 0°, 35°, 45°, 55°, Roll +/- 10°
3. Digital Zoom – Digital PTZ, preset positions
4. Power - Power over Ethernet (POE) compatible and compliant to IEEE 802.3af or 802.3at
5. Network – 100BASE-TX, POE, RJ-45 connector
6. Image sensor – 4 sensors, each 1 / 2.9-inch RGB CMOS
7. Scanning Mode - Progressive Scan
8. Maximum Resolution – 4320 x 1920
9. True Day/Night Capability, automatically removable infrared-cut filter
10. Black and white mode operation - automatically switches from color mode to black and white mode in low illumination
11. Video Compression – motion JPEG (MJPEG) and H.264 (Baseline and High Profile-MPEG 4 part 10/AVC)
12. Video Streaming - 8.3 Megapixel (MP) (client dewarp): 1 individually configurable stream in H.264 and Motion JPEG 7.5 MP (dewarped); 2 individually configurable streams in H.264 and Motion JPEG
13. Maximum Frame Rate – 30 fps at 8.3 MP, 7.5 MP 15 fps
14. The camera must have a weatherproof outdoor enclosure and mounts, must be IK10 vandal resistant with an IP66, IP67 and NEMA 4X rating
15. Capable of operating within the temperature range of -22 (minus 22) degree F to 122 degrees F
16. Humidity – 10-100% condensing
17. Built in blower and/or heater adequate for required temperature range and humidity levels
18. Minimum Illumination - 0.17 LUX color, 0.05 LUX (B/W) at F2.0
19. ONVIF compliant
20. Dome – clear
21. Audio – None
22. SCADA interface – None

23. Security – Password protection, IP address filtering, HTTPS encryption, IEEE 802.1X network access control, centralized certificate management.

2.04 FIXED CAMERAS - ELEVATORS

A. The fixed camera dome system for station elevators must be an Axis P9106-V color fixed dome network camera, or approved equal. The camera must meet or exceed the following specifications:

1. Optical Lens – Fixed focus, fixed iris, 1.8 mm, F2.4, Horizontal field of view: 130°, Vertical field of view: 98°
2. Power - Power over Ethernet (POE) compatible and compliant to IEEE 802.3af or 802.3at
3. Network – 100BASE-TX, POE, 6 ft. cable with RJ-45 connector
4. Image sensor – 1/3-inch RGB CMOS
5. Scanning Mode - Progressive Scan
6. Maximum Resolution – 2016x1512 (4:3), 1920x1080 (1080p) (16:9)
7. Video Compression – motion JPEG (MJPEG) and H.264 (Baseline and High Profile-MPEG 4 part 10/AVC)
8. Multiple, individually configurable streams in H.264 (high profile) and Motion JPEG
9. Maximum Frame Rate – 30 fps
10. The camera must have a weatherproof outdoor enclosure and mounts, must be IK10 vandal resistant with an IP66 and NEMA 4X rating
11. Capable of operating within the temperature range of 5 degree F to 122 degrees F
12. Humidity – 15-85% condensing
13. Built in blower and/or heater adequate for required temperature range and humidity levels
14. Minimum Illumination - 0.35 LUX color
15. ONVIF compliant
16. Dome – clear
17. Audio – None
18. SCADA interface – None
19. Security – Password protection, IP address filtering, HTTPS encryption, IEEE 802.1X network access control

2.05 FIXED INFRARED CAMERA IDS SENSORS

A. Fixed infrared cameras IDS sensors must be an infrared CCTV camera, capable of sensing thermal masses at the intrusion detection system locations, and notifying the SCADA system with intrusion alarms, recognizing that trains are not to be alarmed. Two sensors must be deployed at each IDS location.

B. Camera video analytics must be configured by the Contractor, for detection of persons, animals or objects, within the trackway bounded by the guideway parapet wall, then transversely across the trackway, to the opposite guideway parapet wall; and then longitudinally as far as the camera view will allow. The system must distinguish between trains versus persons or objects, and only alarm when persons or objects enter this defined area. These alarms must be reported via contact closure output from the camera, to the SCADA system remote I/O unit within the IDF/IDS SCADA enclosure.

C. The fixed infrared camera IDS sensor, must be a bullet style camera sensor, Axis Q1942-E 10mm Thermal Network Camera, or approved equal. The camera must meet or exceed the following specifications:

1. Optical Lens – Athermalized 10 mm, Horizontal field of view: 63°, Vertical field of view: 50°–20°, Remote focus and zoom, P-Iris control, IR corrected
2. Power - Power over Ethernet (POE) compatible and compliant to IEEE 802.3af or 802.3at
3. Network – 100BASE-TX, POE, RJ-45 connector
4. Image sensor – Uncooled Micro Bolometer 640x480, pixel size 17 micrometers, spectral range 8 to 14 micrometers
5. Video Compression – motion JPEG (MJPEG) and H.264 (Baseline and High Profile-MPEG 4 part 10/AVC)
6. Three individually configurable streams in H.264 (high profile) and Motion JPEG
7. Maximum Frame Rate - 30fps
8. The camera must have a weatherproof outdoor enclosure and mounts, must be IK10 vandal resistant with an IP66, IP67 and NEMA 4X rating
9. Capable of operating within the temperature range of -40 (minus 40) degree F to 158 degrees F
10. Humidity – 10-100% condensing
11. Built in blower and/or heater adequate for required temperature range and humidity levels
12. Sensitivity – Noise Equivalent Temperature Difference < 50 milliKelvins or lower
13. ONVIF compliant
14. Dome – clear
15. Audio –Two-way, full duplex
16. Audio Input/Output – External Microphone input or line input, line output, all 3.5 mm
17. SCADA interface – Two configurable inputs/outputs
18. Security – Password protection, IP address filtering, HTTPS encryption, IEEE 802.1X network access control, centralized certificate management

19. Software Integration - Open API for software integration, ONVIF compliant, Analytics must include Video Motion Detection, Motion Guard, Fence Guard, Loitering Guard, audio detection, active tampering alarm, and Software platform enabling installation of third-party applications. Must also include event triggers analytics, temperature, external input, time scheduled, edge storage events, and event actions, pre- and post-alarm video or image buffering for recording or upload. Notification via email, HTTP, HTTPS, TCP and SNMP trap.

D. The Contractor must provide Axis Video Management Software or approved equal for this camera, and include all server and workstation licenses as necessary to record video on the DVR at both passenger stations, one central server, and on 3 central workstations, including all software, camera configuration, all accessories and required equipment to provide complete integration of the Video Management Software. The Video Management Software must be compatible with the Infrared cameras sensor selected by the Contractor and approved by VTA.

2.06 PTZ CAMERA DOME SYSTEM

A. The PTZ camera dome system must be a discreet, miniature camera dome system consisting of a dome drive with a variable speed/high speed pan and tilt drive unit with continuous 360 degree rotation with day/night auto switching color/black-white, IP video camera, with optical and digital zoom and auto focus; low-light, Power-over-Ethernet (IEEE 802.3af or 802.3at), compatible with the VTA adopted CCTV client/server/recorder software and rated for outdoor use. The camera must be suitable for outdoor locations, with a 100BaseT Ethernet RJ45 port. Multiple types of mounting equipment must be required, for various mounting requirements. The camera must have the following features as a minimum:

1. Environmental Pendant dome type system with clear dome, gray finish back box, lower dome, for outdoor, weatherproof mounting with fan/blower, heater and sun shield for day and night applications. Ability to provide clear video image at long focal lengths.

2. Dome drive with Day/Night, NTSC, High Resolution Integrated with Optics, built in motion detection and Wide Dynamic Range. Ability to compensate and work in low ambient light environment, window blanking with up to 8 user defined privacy areas and shapes, programmable zones, zoom, scan speeds, limit stops, alarms and patterns including pan, tilt, zoom. Built-in menu system for set up of programmable functions.

B. The pan tilt zoom camera dome system for stations, station platforms and other locations must be a P5635-E Mk II dome network camera or approved equal, including mounting kits and accessories or approved equal. The camera must meet or exceed the following specifications:

1. 360 degrees continuous pan rotation.

2. Optical Lens – 4.3-129 mm lens, Horizontal field of view: 65.6°-2.0°, Vertical field of view: 39.0°–1.2°, Autofocus, auto-iris

3. Optical Zoom –30 X

4. Digital Zoom – Digital PTZ, preset positions

5. Power - Power over Ethernet (POE) compatible and compliant to IEEE 802.3af or 802.3at

6. Network – 100BASE-TX, POE, RJ-45 connector

7. Image sensor – 1 / 2.8-inch RGB CMOS

8. Scanning Mode - Progressive Scan

9. Minimum Resolution – 1920 x 1080 (1080p)

10. True Day/Night Capability, automatically removable infrared-cut filter

11. Black and white mode operation - automatically switches from color mode to black and white mode in low illumination

12. Video Compression – motion JPEG (MJPEG) and H.264 (Baseline and High Profile-MPEG 4 part 10/AVC)

13. Multiple, individually configurable streams in H.264 (high profile) and Motion JPEG

14. Maximum Frame Rate - 30fps

15. The camera must have a weatherproof outdoor enclosure and mounts, must be IK10 vandal resistant with an IP66 and NEMA 4X rating

16. Capable of operating within the temperature range of -22 (minus 22) degree F to 131 degrees F

17. Humidity – 10-100% condensing

18. Built in blower and/or heater adequate for required temperature range and humidity levels

19. Minimum Illumination - 0.25 LUX color, 0.02 LUX (B/W) at 50 IRE F1.6

20. ONVIF compliant

21. Dome – clear

22. Audio – One-Way or Two-Way streaming

23. Audio Input/Output – External Microphone input or line input, line output

24. SCADA interface – four configurable alarm inputs/outputs

25. Security – Password protection, IP address filtering, HTTPS encryption, IEEE 802.1X network access control, centralized certificate management

2.07 INFRARED ILLUMINATORS FOR SIGNALS, TRACKWAY, TPSS CAMERAS

A. The CCTV cameras including PTZ and Fixed cameras, for areas with inadequate nighttime lighting including those for the trackway, signal cases on the trackway, and TPSS, must be equipped to operate on infrared light so that images must be clear, even in very low light conditions. The cameras must have separate infrared illuminators mounted below the CCTV cameras on a separate mount. The infrared illuminator must meet or exceed the following specifications:

1. Illumination wavelength compatible with camera selected

2. Illumination level sufficient for the distance to object

3. Equipped with a photocell, to automatically turn infrared illuminator on during low light conditions, and turn it off when sufficient ambient lighting is available (day/night operation)

4. Operates on 24/28 VAC power supply

5. All IR Illuminators must be the same manufacturer

2.08 CONDUIT BACK BOXES AND LOWER DOMES

A. Back boxes and lower domes must meet or exceed the following design and performance specifications:

1. Operating Temperatures – Ability to support camera's continuous operation in the ambient temperature specified.

2. Weather Resistant - IP66 waterproof and dust resistant rated

3. Supplied with blower and heater

2.09 MOUNTING SYSTEMS & ACCESSORIES

A. Mounting systems, brackets, hardware and related fasteners and equipment must be provided, including those systems for wall, ceiling, standard VTA light poles, custom IDS sensor poles, large diameter OCS poles, TPSS exterior, Signal case exterior, and all other mounting required. The Contractor is responsible to ensure compatibility between camera equipment and mounting systems and accessories.

B. Furnish and install CCTV NEMA 4 boxes in the shelter canopies and accessories as required for a fully functioning system. Provide one box for power supply, and one for communication equipment.

C. Furnish and install power supplies, Ethernet cable termination blocks, receptacles and other electrical and mechanical accessories inside the CCTV boxes as necessary.

D. Furnish and install, factory made jumper/patch cords, media interface and cable termination accessories as necessary to accommodate new Ethernet cable terminations.

E. Furnish and install edge switches, media converters and/or hubs with power supplies inside NEMA 4 boxes, sized as necessary, Hoffman or approved equal.

F. Provide custom keyed commercial grade padlocks for all NEMA 4 boxes, Master Lock model 1KA. VTA must provide the key number.

G. Acceptable camera mounting components, as they are compatible with the required cameras, include but are not limited to the following:

1. Axis T91B61, wall mount or approved equal.

2. Axis P33-VE, network cameras pendant kit or approved equal.

3. Axis T91A67, pole bracket or approved equal.

4. Axis T91B62, parapet mount or approved equal.

5. Axis T94R01P, conduit back box or approved equal.

6. Axis T8133, midspan 30 W 1-port or approved equal.

2.10 CAMERA POWER DISTRIBUTION

A. Camera power supplies if required must be:

1. Capable of powering discrete/independent camera locations with a 20% overage allowance

2. Have the capability to support all cameras connected to them with all blowers or heaters (whichever requires the most power) running simultaneously

3. Rack-mountable, wall-mountable, panel mountable on DIN Rails

4. Operate on 120 VAC, 60Hz input with 24/28 VAC, or POE output

5. Acceptable power supplies include:

    a. Altronix, R2416UL, rack mount power supply or approved equal.

    b. Altronix, ALTV244300WP, power supply or approved equal.

2.11 DIGITAL VIDEO-RECORDERS

A. Furnish, install, configure and test new CCTV Video storage DVR servers along with Ethernet interfacing equipment and accessories such as patch cords, etc. to interface with the VTA's existing network equipment for monitoring and storage of video images at local and remote VTA sites. Contractor to coordinate with Resident Inspector and VTA technology department for proper IP addresses, and other network interfaces and compatibility issues before ordering new equipment.

B. Provide local DVRs with Video Storage in the IT Communications equipment room at each passenger station, compatible with the existing exacqVision VMS software, Enterprise Server Option, EVES-0l and the existing HP ProLiant ML350p Gen8 Video Server at the Operations Control Center at Rail Operations and other facilities.

C. Provide the latest model DVR as shown on the Contract Drawings, including software at the time of the installation compatible with the current VTA Information Technology CCTV System Application Software.

D. The DVR must be a rack mounted server computer, with factory integrated peripherals and equipment, with the same type and version of operating system as existing VTA DVR servers, including exacqVision VMS software, enterprise server option, EVES-01 or approved equal.

E. The DVR Application software must support "water-marking" of the stored video or use some other technique admissible in the court of law as a proof that the submitted video evidence was not tampered with. This digital signature or hashing method must preserve the chain of evidence.

F. The DVR operating system systems must be compatible with current VTA Information Technology CCTV System requirements, including the existing operating system and the CCTV application Software. Assist VTA with coordination of this process if, at the time of installation, the systems have changed to a newer operating system or a more recent Central CCTV Application Software is desired.

G. The CCTV System software must support conventional and digital PTZ functionality.

H. The DVR must provide simultaneous recording, remote viewing and management of a minimum of 64 cameras at 30 frames per second, full resolution viewing and simultaneously 15 frames per second, full resolution local recording using High Efficiency Video Coding (H.264) compression.

I. The DVRs must have a high-speed IP interface, as required to obtain the required remote viewing rate, connectivity for transmission of the video IP-traffic to the Rail Operations Center/Operations Control Center (OCC), VTA Protective Services, and VTA Administration via the Communications Transmission System (CTS).

J. The DVR must be SNMP compatible and configured to be managed by VTA`s existing NMS, the Contractor must configure the DVR.

K. The DVR must be based upon a fully modular architecture, allowing for upgrades for additional recording capacity in the future.

L. The system must simultaneously display live playback and recorded video while continuously recording video.

M. Recording operation must not be interrupted, or stop for playback or live viewing. The system must simultaneously display live playback and recorded video while continuously recording video.

N. The supported compression formats must be:

1. MJPEG
2. MPEG4
3. H.264

O. Provide all licenses necessary to provide a complete and functional system.

P. Provide all software upgrades during the 1-year warranty period at no additional cost to VTA.

Q. All equipment and materials used must be standard components that are regularly manufactured and utilized in the manufacturer's system.

R. Provide additional components required to provide a complete and operable system.

S. Provide sufficient hard disk space for 14 days storage of continuously recorded video for all camera inputs interfacing to each DVR. The station DVR must support the video input and storage from all CCTV System and Intrusion Detection cameras associated with the station. The video images/video streams must be recorded from both standard CCTV cameras and Megapixel CCTV cameras. For purpose of storage space, all cameras must be recorded at a 1080p resolution (1920x1080), at 10 FPS, 24 hours day, 7 days per week.

T. The DVR at each station must have the expansion capability to input the video from additional cameras either by adding additional storage, adding an external storage system or by the addition of another DVR server.

U. All systems and components must have been thoroughly tested and proven in actual use by other transit agencies.

V. Network Requirements:

1. The DVR must support a minimum of two separate network interface cards (NICs).
2. The NVR must include support for the following network segments:
   a. Video collection network – the network in which video is collected and transported over an IP network to the DVRs.
   b. Video viewing network – the network in which video is transported over an IP network to remote or local devices, which display the video data on analog or digital displays.
3. Network segment assignment options:

a. The NVR must be configured with different network segment assignments for each of the NICs

b. The NVR must be configured with different network segment assignments on the same NIC

4. The DVR must support the following network protocols in the collection network:

   a. Real Time Protocol (RTP)

   b. User Datagram Protocol (UDP)

   c. Transmission Control Protocol (TCP)

   d. Internet Protocol (IP)

   e. Hyper Text Transfer Protocol; (HTTP)

   f. Real Time Streaming Protocol (RTSP)

5. The DVR must support the following network protocols in the viewing network:

   a. RTP

   b. UDP

   c. TCP

   d. IP

6. The NVR must support the following networking environments for the NVRs to workstations:

   a. Local workstation over LAN where the streaming is done by multicast

   b. Local workstation over LAN where the streaming is done by unicast UDP

   c. Local workstation over LAN where the streaming is done by unicast TCP

   d. Remote workstation over narrowband WAN is done by multicast

   e. Remote workstation over narrowband WAN is done by unicast UDP

   f. Remote workstation over narrowband WAN is done by unicast TCP

7. The NVR must be capable of recording and monitoring cameras in different frame rates. Each channel configured in the NVR must have an individual setup for the following settings:

   a. Brightness

   b. Contrast

   c. Color

   d. Sharpness

   e. Saturation

   f. Hue

g. White balance

W. The DVR must be a rack type server, not mounting on rack trays.

X. The DVR must be a Hewlett Packard HPE Proliant DL380 Gen10 (part number 875759-S01) server, approved equal or better with the following features, and support services from Hewlett Packard. The following list is only key equipment and services, the Contractor must provide a complete solution, including any required equipment, accessories or components, to make a fully functional and completed DVR solution:

1. Processor - one 4-core 4112 2.6 Ghz processor (part number 875759-S01)
2. Memory – HPE 16 GB DDR4 Ram (part number 875759-S01)
3. Drives, Operating System, Applications – two 480 GB SATA Drives, 6Gbps Mixed use LFF (3.5inch, 960 GB), (part number 819201-B21), mirrored with OS, Applications on each
4. Ethernet NIC (Network Interface Card) – HPE FlexFabric with two (dual) 10 Gbps interfaces (2-port) 534 FLR-SFP+ Adapter (part number 700751-B21)
5. Power Supplies – two (dual) 500 watts each, hot swappable
6. Fans – Hot plug fans, two (redundant), removable, hot swappable
7. Power Supplies – two (dual) 500 watts each, removable, hot swappable
8. Started Up Service - HPE Installation and Startup Service (part no. HA114A1)
9. Support Service – HPE DL38x Gen10 Support (part no. H1K92A3WAH)
10. Extended Service - HPE 3 year Proactive Care 24x7 SVC (part number H1K92A3)

Y. The DVR must provide alarms (via SNMP) for the connected CCTV storage devices as part of the DVR to the network management system in the following conditions, the Contractor must be responsible for configuring the existing VTA network management system, or in support of that configuration by VTA as selected by VTA:

1. Power supply alarm
2. Fan alarm
3. Temperature alarm
4. Redundant Array of Independent Discs (RAID) failure/trouble
5. Bad disk
6. Operating system or other software or configuration problem

Z. The DVR must also have the following functionality:

1. Ability for failure of the DVR to be detected and automatic rerouting of the video images to a remote backup DVR.
2. Time stamp each of the camera images. Timing source must be by VTA provided NTP source over the high-speed IP network.

3. Video signal loss detection

4. Video alarms must be reported through the Axis VMS system

5. The DVR must be rated to operate in a seismic zone environment, as identified in the California Building Code.

2.12 DVR VIDEO STORAGE

A. DVR Video Storage must be integrated as part of the DVR, including support services for the DVR and DVR storage, as specified with the DVR. Sufficient video storage must be provided as specified, the storage specified below is the minimum required. The Contractor must provide more storage than the minimum if required to meet the specified storage requirements. The Video Storage System must be the following or approved equal. The following list is only key equipment, the Contractor must provide a complete solution, including any required equipment, accessories or components, to make a fully functional and completed DVR Video Storage solution:

1. Storage Controller – one HPE Smart Array P480i-a, RAID 10 configuration for Storage

2. Minimum Storage, Contractor to provide storage capacity as specified – Four HPE 8TB SAS Drives, 12 Gbps Midline, 7.2K rpm LFF (3.5-inch, 32 TB)

3. Local Video Storage in the DVR must be sized to store images, from all cameras connected, for 14 days at 4CIF at 30 frames per second, or full resolution at 15 frames per second, plus 25 percent, whichever is greater, but no less than 24 terabytes.

4. The video storage configuration must be a RAID 10. No failure of a disc, disc controller, power supply, or computer I/O bus interface must interrupt recording or cause the video to become unavailable.

5. Hard Drives and power supplies must be hot swappable.

6. Microsoft Windows Server 2019 Standard Edition Operating System, with client access licenses as required.

7. Commercial-off-the-shelf (COTS) backup/restore equipment, software, and storage media must be provided for the video storage, compatible with existing VTA software.

8. The video storage must be rated to operate in a seismic zone environment, as identified in the California Building Code.

2.13 MAINTENANCE KVM CONSOLE DRAWER AND KVM SWITCH

A. A rack mount console used for programming the digital video recorders must be provided for each station, and a second rack mount console must be provided within each communications room for SCADA and related systems. The rack mount console must include a monitor, keyboard and touchpad. The rack mount console must meet or exceed the following specifications:

1. Compatible with most USB type KVM switches, to match provided computer equipment provided by the Contractor.

2. Integrated KVM console (88 key keyboard and touchpad) in a 1U rack mountable slide-away housing.

3. Provide a USB port on the front of the keyboard for USB pass through.

4. Rack mountable in 19” system rack (1U).

5. Built-in three button touch pad, 4 scroll keys.

6. Monitor: LED/LCD flat panel type, for 19” system rack.

7. Monitor Resolution: 1920x1080 (1080p) minimum.

8. Metal enclosure.

B. A rack mount KVM switch must be used for configuring the digital video recorders and must be provided for racks in each station IT room, and within each communications room for SCADA and related systems. The KVM switch must meet or exceed the following specifications:

1. Use of keyboard, monitor and touch pad to control up to eight computers

2. Multilevel password protection

3. Quick view scan mode for monitoring selected computers

4. Operating System-independent operation

5. Connected PC can be added or removed from the setup without powering off the KVM switch

6. Plug-n-Play monitor support

7. Minimum video resolution of 1920x1080 (1080p)

8. LED, LCD monitor support

9. Mouse and keyboard emulation for system bootup

10. No software required to operate

11. LEDs for easy status monitoring

12. Rack mountable in 19" (1U) system rack

2.14 SYSTEM INTERFACES

A. Communications Interface: Communications facilities between the River Oaks Protective Services and VTA IT CCTV server/client equipment and the new CCTV System must be provided under this Contract. The new CCTV System must interface with the Station IT LAN.

B. All IT CCTV cameras must connect and interface with the Station IT LAN, either directly or through remote IT IP switches for Stations, Station Platforms, Station equipment rooms, IDS, and TPSS.

C. The IT CCTV Cameras must contain an SNMP agent necessary for the LAN manager to perform all required performance monitoring, configuration control and diagnostics. The agent must include all available manufacturer’s MIBs which report the operating state or allow the remote configuration of the CCTV Camera.

D. The IT CCTV system must provide alarm outputs from CCTV cameras hardwire connected to the SCADA PLC/PAC directly, or through Remote I/O units, to provide the specification required alarms for trackway intrusion, for trackway adjacent to passenger station boarding platforms only.

E. IDS Infrared sensor cameras are not part of the IT CCTV system, are a separate system, and must interface with the Station SCADA LAN, either directly or through remote SCADA IP switches for IDS.

PART 3 - EXECUTION

3.01 FACTORY TESTING

A. Qualification testing, representative of production runs of equipment and materials must be documented by the manufacturer and must be provided for each shipment of equipment. Provide FAT record to VTA for approval.

B. Prior to delivery to the site for actual installation, shop-assemble and test all devices. Fully test and demonstrate that each is a correctly working device.

C. The Contractor must fully configure and test each camera prior to installation.

D. All equipment, including cameras, DVRs, rack mounted equipment delivered as racks to the Project Site, must be factory tested as required by these specifications, and approved by VTA, prior to shipment to Project Site.

3.02 INSTALLATION

A. GENERAL

1. The CCTV equipment required by this Section must be located according to the Contract Drawings along the LRT right-of-way, stations and facilities, and at locations as required to meet the functional requirements.

2. The Contractor must be responsible for proper placement of all equipment to ensure required operating clearances around all equipment. Further, the equipment location must take into consideration maintenance access and safety to maintenance and operations personnel.

3. In all cases the Contractor must locate the CCTV equipment to ensure proper operation of the equipment.

4. The Contractor must install cameras to capture the designated areas specified by VTA. The camera views should provide adequate coverage and not be blocked by other cameras, other communications devices, equipment provided by others, columns, trees, or structures. Final adjustment of the field of view of the cameras must be an interactive process between the Contractor and VTA after all cameras have been mounted and tested.

5. Programming for initial tours and salvos must be provided as requested by VTA. This programming must be for a minimum of six preset positions per PTZ camera.

6. Locations of the camera shown on the Contract Drawings are generally correct. The Contractor must assume the cameras can move up to ± 15 horizontal and/or vertical linear feet from the location shown.

7. As shown on the Contract Drawings, cameras are mounted on light poles or shelters or Contractor provided surveillance poles. The Contractor must install the cameras to ensure that Contractor supplied mounting provisions are adequate and matches the architectural treatment of the shelter or pole. Wiring to cameras in shelters shall be routed through structural steel tubing, contractor shall coordinate this wiring and required access panels and pull points with other disciplines. All mounting hardware to be approved by the Engineer. Mounting hardware must be primed and painted black, except for banding straps, which must be unpainted stainless steel.

8. Installation Plan: Installation of the CCTV equipment must be conducted according to the approved Installation Plan. The CCTV Equipment installation must not commence prior to VTA approval of the Installation Plan for each corresponding type of equipment installation.

B. MATERIAL RECEIVING/SHIPPING/STORAGE

1. The Contractor must inspect and test all supplied equipment at time of delivery to the construction site to assure that no damage was done in shipping and that the specified equipment was received. A copy of these inspection reports must be submitted to VTA.

2. All electrical equipment including CCTV equipment and supporting hardware such as connectors, cables, patch cords, mounts must be inspected by the contractor at the time of delivery to the construction site to assure that no damage was done in shipping and that the specified equipment was received. All damaged material and equipment must be replaced by the contractor at no cost to VTA. Contractor is responsible for furnishing and installing the proper hardware, mounts and accessories depending upon the CCTV field applications and as recommended by the equipment manufacturer.

C. CONDUITS/PATHWAYS INSTALLATION

1. New conduits must be provided to complete the pathway from the conduits provided by others to the cameras, CCTV NEMA 4 boxes, IT or Communications Room, and other CCTV equipment. The new conduits must be provided whether shown on the plans or not.

2. Confirm conduits are clean and free of debris etc. prior to routing new cables to avoid any cable damage.

D. CAMERA MOUNTING & EQUIPMENT INSTALLATION

1. Install all components to provide aesthetically pleasing results. Coordinate the actual locations of all visible components in advance with the VTA.

2. Cameras must be mounted in locations least susceptible to damage and/or vandalism.

3. Locate all cameras according to plan drawings. Coordinate with the VTA and obtain approval for each camera mount/enclosure locations, as well as view angles and lens settings.

4. Install all cameras on the mount/enclosure specified, ensuring that mounting location and method provide the necessary camera stability to meet system performance standards. Types of cameras and their respective mount/enclosures are identified in the camera details and as directed and approved by the VTA.

5. All equipment installations must be in compliance with the specifications, contractual drawings, applicable codes, and manufacturer recommendations.

6. The contractor must utilize existing poles and structures for the mounting of cameras, in accordance with the approved design. Any modifications to the existing equipment or specified mounting details must be approved by the VTA.

7. Contractor must follow the CCTV camera and camera housing manufacturers' recommendations for mounting, wiring and installation of the CCTV camera and the camera enclosure.

8. Apply anti-seize lubricant on all camera mount threads.

9. Cameras, CCTV NEMA 4 boxes and power supplies must be sealed watertight.

10. Paint all Contractor furnished and installed pull boxes, junction boxes, enclosures, and conduits to conform to paint color selected by the VTA.

11. Any required 24 VAC camera power or other low voltage cables as applicable, must share the conduits and be pulled along with the CAT6 to cameras. Any 120 VAC power must be installed in conduits separate from the communication conduits.

12. All connections to the cameras must be plug connectorized to facilitate quick removal and replacement of the entire dome housing and camera assembly.

13. Onsite pre-operational test activities include tests and inspections that must be performed prior to any operational testing of systems or subsystems.

14. Following the installation, the Contractor must inspect the equipment to verify that all approved equipment is installed in its proper location in accordance with the approved design, marked for identification, and all wiring is properly terminated and labeled. Contractor must verify that all mechanical connections are made and secure.

15. A test procedure for all copper cable installed must be prepared by the Contractor and supplied to the VTA for review and approval. Local area network cabling: The procedure must include the use of a Category 6 cable tester capable of testing unshielded twisted pair up to a minimum of 100 MHz frequency. Tests must be performed in accordance with TIA/EIA 568 and the cable test set instructions.

16. Cables must be tested for continuity, loop resistance, insulation resistance, shield continuity, cross talk, and impedance. Tests must be performed in accordance with the tests for each installed cable run must be performed and recorded on electronic media by the Contractor.

17. Contractor must also perform end (existing VTA Ethernet network switch) to end (the CCTV camera) cable tests on all utilized cables to ensure proper video signal quality. A signal to noise (S/N) ratio of more than 58-60db would be acceptable.

18. Contractor must verify that all cables are properly routed, supported, terminated and labeled.

19. Contractor must check all existing circuits and conditions for safety prior to performing all required circuit, cable and CCTV system tests. The contractor is to ensure that existing.

20. The Contractor must verify that electrical, environmental, and mechanical specifications for all installed equipment are appropriate and compliant with all codes for each location in which it is installed prior to installation, and include verification of readiness.

21. Contractor must verify that all equipment is the appropriate model, properly installed and connected in accordance with the approved design and manufacturers' requirements.

E. WIRE & CABLE INSTALLATION

1. Furnish, install, terminate and test new CCTV video network cables between various cameras and CCTV equipment in the field. Terminate new Ethernet cables as necessary to interface with the existing network switches to route video signals over the VTA network to monitor remote sites. Provide new terminating accessories as necessary to properly terminate cables and interface with the existing network equipment. Contractor to coordinate with Resident inspector and VTA technology department for proper IP addresses, and other network interfaces and compatibility issues before ordering new equipment.

F. SETUP & CONFIGURATION

1. The Contractor must follow the following as minimum for camera setup and configuration:

   a. Minimize glare from sun exposure (at any time of day/time of year) or lighting.

   b. Final aiming/positioning of each camera must be approved by the VTA.

   c. Perform back focus (bench setup acceptable).

   d. The lens aperture must be wide open for all back focus adjustment procedures. Therefore, procedures must be performed in subdued lighting or with the use of welding glass in front of the lens to reduce the light.

   e. Auto Iris (bench setup acceptable).

   f. Follow the manufacturer's adjustment procedures.

   g. Adjust camera aiming, automatic gain control, back light compensation and lens settings with approval required by the VTA for picture quality during day and night operation.

   h. White Balance (bench setup acceptable).

   i. Motion Areas: The Contractor must provide programming of detection area and sensitivity for each camera and must obtain approval from the VTA prior to acceptance.

   j. Camera coverage must not include private or residential areas or areas where there is an expectation of privacy.

2. After all cameras have been configured, the Contractor must submit a camera configuration spreadsheet containing at a minimum the following:

   a. Video frame-per-second/image-per-second rate

   b. Video resolution

   c. Alarm settings

   d. Lens setting

   e. Camera positioning

   f. Camera IP settings

3. The Video Surveillance Software must be installed with the full support of the manufacturer of the security system components.

4. Provide the entire programming and setup of the system such that no additional programming is required. Programming to include the setup of all applicable features of the software. No additional configuration or programming must be required by the VTA. All configuration and programming must be done by the Contractor.

5. Perform two full system back-ups on DVD at completion of initial programming and deliver one copy to VTA with letter of Transmittal explaining information included in back-up and brief description of recovery procedures. The second backup must be labeled and remain onsite. Perform back-ups as modifications to the database/programming occur through the remainder of the project onto DVD and provide to the VTA.

6. Configuration and programming information must be captured for every DVR, video server and video management workstation. This must include data files, screen shots of configuration settings and source code of any custom applications developed for the Project, including scripts.

7. Configuration Control: Maintain spreadsheet of software configuration and programming version number for every DVR, video server and video management workstation including description, date, time, version number and provide to Owner with each system backup.

8. The Contractor is responsible for all necessary programming of the CCTV equipment to make a fully functional CCTV system. This also includes installation of all applicable software patches and firmware upgrades.

3.03 CCTV SYSTEM SIGNAGE

A. At the locations approved by the VTA, the Contractor must install signs stating that the areas are under video surveillance. Prior to the installation, the design and mounting of the signs must be approved by the VTA.

3.04 TEST AND MAINTENANCE EQUIPMENT

A. The Contractor must provide sufficient test equipment to verify the requirements of these Technical Specifications.

3.05 TESTING

A. GENERAL

1. The contractor must install, program, test, and place the CCTV systems into satisfactory operation. All installation must be in accordance with manufacture’s specifications and instructions. All tests must be witnessed and subjected to approval by VTA. Notify VTA at least 48 hours prior to testing.

2. The Contractor must perform all work necessary for planning and conducting the required tests. The Contractor must also prepare the required documentation for the performed tests.

3. When any system or subsystem does not meet the requirements of this Specification, the work in this Contract includes making necessary corrections and retesting to prove compliance and acceptance by VTA.

4. The Contract must supply required test equipment of the proper type, capacity, range and accuracy for the tests at no additional cost to VTA. This equipment must be in good working order and properly calibrated at the time of the tests.

B. INSTALLATION VERIFICATION – FIELD INSTALLATION TEST

1. Installation Test Procedures: Installation testing of the CCTV equipment must be conducted according to the approved Field Installation Test Procedures. The CCTV Equipment installation must not commence prior to VTA approval of the Installation Plan for each corresponding type of the equipment installation.

2. Installation of the CCTV Equipment: Installation and testing of the CCTV equipment must include the following activities:

   a. Pre-installation/test inspection of available space and power, grounding system, cable runs and/or conduits, device terminal blocks, documentation on device terminal block wiring and testing performed by others.

   b. Confirmation of the physical inventory data and pre-installation visual inspection of CCTV equipment.

   c. Post installation inspection of all equipment, mounting, cabling, and wiring.

3. Testing of Installed CCTV Equipment: Testing must be completed and records must be maintained for all CCTV Equipment installation and test activities, and must be delivered to the VTA. Tests must include as a minimum:

   a. Equipment diagnostics.

   b. Data communications testing for communications between the CCTV equipment and the Central Management Facilities.

   c. CCTV Signal testing for each input.

   d. Video quality and focus.

   e. Full camera functionality.

   f. Device and alarm testing using the local and remote test sets and verification of the associated Device Interface Management Database.

4. Configuration and testing must cover, at a minimum,

   a. Verify correct termination of all field wiring and inter-facility cabling using Contractor-prepared interconnection diagrams.

   b. Verify that physical construction has been completed in accordance with the plans and Contract Specifications.

   c. Inspect quality and tightness of ground and surge protector connections.

   d. Verify power supply voltages and output prior to connection of devices to power source.

   e. Verify installation of specified cables and connections between camera units, media converters, power supplies, network switches, video workstations and video servers.

C. FUNCTIONAL AND PERFORMANCE TESTING

1. Following installation, the Contractor must conduct a VTA witnessed test to verify the system parameters.

a. VTA must be given 15 days advance notice of the date the installation will be ready for final testing so that VTA may witness the tests, if it so elects.

2. The requirements for testing to be performed under this Contract, including the criteria and requirements for test planning, performance, recording of data and reporting of test results. Requirements for Pre-operational and operational Acceptance Tests are included below.

3. On-site technical assistance from the Contractor must be provided for system installation, on-site Operational Testing, Integrated System Testing and Final Acceptance.

4. General: After the system is completely installed in accordance with the Specifications, Drawings, and Details, Contractor must conduct a full systems test. The contractor must perform all manufacturer recommended tests for CCTV and electrical equipment. All equipment configuration, management and diagnostic functions must be exercised and demonstrated as operational. All methods and tools used to perform tests must be documented in hardcopy and any application software used for testing must be supplied to VTA in electronic format. Provide a copy of the record of test results to the VTA. Use the test procedures submitted as approved by VTA, to test and evaluate the system. These tests must be part of the overall Final System Acceptance Testing requirements. All tests must be performed and signed off for each device in the system. All results of the tests must be documented, witnessed and signed by VTA inspector and an electronic copy be submitted to VTA for final acceptance. Practical Completion will be effective after twenty-four consecutive hours of uninterrupted, fault free operation.

5. All tests must be performed and signed off for each device in the system, for each camera, when applicable:

   a. Coverage: Verify coverage areas are achieved as approved by VTA.

   b. Video Signal: Video levels, Alarm outputs, picture quality, focus.

   c. Functionality: Complete camera functionality including PTZ controls.

   d. Power Supply Characteristics: Output voltages, protective features, etc.

   e. In the test procedure for the CCTV System, each camera and all associated video transmission devices and cables must be tested for a good crisp video signal.

   f. Verify proper integrated operation of all CCTV system elements, including cameras, local (laptop) and then remote CCTV client/server viewing/management software used by VTA. This must include simultaneously viewing CCTV images at various resolutions (approved by the VTA) using live video, recording live video; and downloading stored video.

6. The transmitted video signal and all applicable CCTV System controls, indications and alarms must be verified at first locally (at the stations) using portable laptops loaded with the VTA-specified software. After successful local testing, after approval by the VTA, the Contractor must follow up with a similar testing of the CCTV System using “end-to-end” approach (from VTA Central Facilities to the CCTV cameras).

7. The Contractor must perform all functional tests to confirm the CCTV system meets all functional criteria established as a part of the design process and approved by VTA.

8. In the absence of manufacturer-defined tests, use a copy of the system’s operator manual to define tests that demonstrate the operation of each system function. The Contractor and Owner must initial and date each function successfully demonstrated and include the pages in the testing binder.

9. Demonstrate the operation of all video surveillance equipment, exercising the pan, tilt, zoom, focus, iris opening, manual iris and power on/off functions while observing the video picture on a laptop computer connected to the camera or station/facility LAN switch.

10. Demonstrate that camera sensitivity at low light levels meets the manufacturer's specified requirements.

11. Demonstrate the field of view of each camera is unobstructed and provides the intended coverage.

12. Adjust camera position or relocate cameras as required.

13. Tests must include multiple video management workstations, multiple video recorder and video servers performing simultaneous end to end functional tests using every camera type, for the following tests:

    a. Viewing QCIF, CIF, 4CIF, 108p and High Resolution (megapixel) live video and recording live video; downloading stored video to multiple video management workstations while backing up stored video locally onto DVD and CD ROM to (including water-marked videos).

    b. The DVR must demonstrate that the video output of the cameras at each station will meet or exceed the 2 week requirement. This must be demonstrated while the station is in normal use and must not include any system failures which would limit the video recording.

    c. Testing of the DVR must start with local testing at each station then progress to the remote workstations as the system is demonstrated to be functional at each level.

14. An electronic copy of all test reports containing the results of all measurements must be submitted to the VTA for approval. The test equipment manufacturer's instructions for operation and electrical connections must be followed.

15. Problem Resolution – VTA will report functional problems encountered during the test period to contractor. Contractor must provide a convenient mechanism to record each problem and track the progress toward resolving each problem. Contractor must develop and install corrections to the reported problems and must perform verification to ensure changes do not introduce other problems. All system changes must be performed in accord with Contractor's change control and configuration management procedures.

D. SYSTEMS INTEGRATION TESTING

1. Demonstrate the correct operation of all CCTV cameras viewing and control from VTA Operations Control Center at the Younger Maintenance Facility and at the River Oaks Facility.

2. Demonstrate remote access to locally stored video images from VTA Operations Control Center at the Younger Maintenance Facility and at the River Oaks Facility.

3. Demonstrate the correct operation of Video Analytics Intrusion Detection for the IDS Infrared Cameras and Station 180 Degree cameras for intrusion detection with alarms to the SCADA system, for Trains, persons, and test objects.

4. Demonstrate the correct operation of the Video Analytics for CCTV cameras throughout station areas, demonstrate for all station levels, all cameras.

5. Contractor must support any additional Systems Integrated Testing requested VTA to ensure full functionality with all existing systems of which the CCTV system is a part, such as testing infrared IDS cameras with movement of trains.

3.06 FIELD QUALITY CONTROL

A. Quality: The quality of the Communications System installation must be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Contractor must perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications and workmanship standards and practices.

3.07 TRAINING

A. Maintenance Training must include the following:

1. Instruction and "hands-on" demonstration of the operation of all system components and the entire system including program changes and functions
2. Equipment settings and test procedures
3. Equipment replacement
4. Video Back-up

B. Operations Training must include the following:

1. Operation and configuration of the camera monitoring software.

3.08 SPARE PARTS AND TOOLS

A. Spare parts and tools must be provided as specified.

3.09 WORK TO BE PERFORMED BY VTA

A. VTA will make personnel available in VTA Central Monitoring as required to support testing from that location.

3.10 WARRANTY WORK

A. In addition to the requirements of General Conditions, GC-74 Warranty Work, the following also applies to the CCTV equipment.

1. Contractor must provide a contact and phone number for warranty work.
2. Response time for warranty work must be within 48 business hours.

END OF SECTION

SECTION 28 31 00

INTRUSION DETECTION SYSTEM (IDS)

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes requirements for the Intrusion Detection Equipment to be provided, installed, configured and tested by the contractor. The Intrusion Detection Equipment must be provided as shown on the Contract drawings. The Contractor must also provide and install all necessary enclosures and cabling and related equipment as shown on the Contract drawings.

B. The Intrusion Detection Equipment alarm indications must be terminated at the IDS Remote I/O unit which then connects to the station SCADA PACs/PLCs via the CTS. The Contractor must implement all necessary termination, configuration and software changes to the Remote I/O Units, PACs/PLCs and the SCADA to provide for a fully functional and integrated Intrusion Detection System.

C. Requirements for the Intrusion Detection System CCTV Cameras are in Section 28 20 00, Video Surveillance (CCTV).

D. This Section includes requirements for the SCADA CCTV Infrared/Video Analytics and Alarming that will report to the YMF CCS, but the Infrared Cameras are included in Section 28 20 00, Video Surveillance (CCTV).

E. This Section includes requirements for Optical Beam Sensor Arrays, LIDAR Sensors, Visual and Audible Alarms to be utilized at the IDS locations including interface to the SCADA System.

1.02 RELATED SECTIONS

A. Section 27 05 00, Common Work Results for Communications

B. Section 27 05 28, Pathways for Communications Systems

C. Section 27 11 16, Communications Cabinets, Racks, Frames and Enclosures

D. Section 27 11 19, Communications Terminal Blocks and Patch Panels

E. Section 27 13 00, Communications Network Cabling

F. Section 27 15 00, Communications Low-Voltage Conductors and Cables

G. Section 27 21 00, Communications Network Equipment

H. Section 27 26 00, Communications Programming and Integration Services

I. Section 27 30 00, Telephone System

J. Section 27 42 19, Public Address System

K. Section 27 42 20, Passenger Information Monitor System

L. Section 28 20 00, Video Surveillance (CCTV)

M. Section 28 40 00, SCADA Monitoring and Control System

1.03 REFERENCED STANDARDS

A. The latest versions of the following standards and references apply to the work included in this Section, in addition to those codes and standards common to all communications subsystems specified in section 27 05 00, Common Work Results for Communications. If a conflict must arise between various standards, the California state code amendments must govern, or the most strict/conservative requirement must govern.

B. STANDARDS: Standards and codes produced by the following organizations are referenced throughout these Technical Specifications and must apply to the work performed:

1. National Electrical Code (NEC)
2. California Electrical Code (CEC)
3. National Electrical Safety Code (NESC)
4. Insulated Cable Engineers Association (ICEA)
5. American Society for Testing and Materials (ASTM)
6. American National Standards Institute, Inc. (ANSI)
7. Underwriter's Laboratories, Inc. (UL)
8. California Occupational, Safety and Health Administration (OSHA)
9. Building Industry Consulting Service International (BICSI) Telecommunications Distribution Methods Manual
10. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA)
11. Institute of Electrical and Electronics Engineers (IEEE)
12. Federal Communications Commission (FCC) Rules Parts 15 and 90
13. National Fire Protection Association (NFPA) Standard 130
14. National Electric Manufacturer's Association (NEMA)

1.04 QUALITY ASSURANCE

A. Software Quality Assurance: The Contractor must plan, implement, administer, and maintain a comprehensive software and hardware quality assurance program, conforming to IEEE.

B. Past Performance and Experience: The Contractor must demonstrate previous successful experience installing Intrusion Detection equipment.

C. Inspection: VTA reserves the right to make inspection and tests as necessary to determine if the Intrusion Detection System installation meets the requirements of these technical specifications. VTA reserves the right to reject any part or all of the installation that is defective in any respect. VTA reserves the right to request additional tests to provide further satisfaction that the Intrusion Detection System has been installed in accordance with the requirements of these technical specifications at no additional cost to the Contract.

SUBMITTALS

Design Information:

Conceptual Design Review: The Contractor must submit the following information as part of the CDR: Separate IDS block diagrams for Intrusion Detection areas.

1.05 Preliminary Design Reviews:

A.

1. The Contractor must submit the following information as part of the Preliminary Hardware Design Review submittal:

2. 1) Description of the IDS System elements' configurations, with detailed block diagrams.
a. Configurations for each Intrusion Detection area must be included.

2) IDS equipment data sheets.

3) IDS equipment reliability analysis including the MTBF for a typical IDS sensor equipment and IDS LAN Switch.

Final Design Review information: The Contractor must submit the following information:

3. As part of the Hardware Final Design Review submittal - Detailed cable drawings, schematics
a. and equipment and I/O wiring diagrams for each type of location (e.g. station, Intrusion Detection area, etc.) where the IDS equipment is located or terminated.

B. Test Procedures: As part of the Communications System As-built documentation, include:

1. Prior to the IDS equipment testing, the Contractor must submit test procedures for the approval by the VTA. As a minimum, the test procedures must meet the testing requirements found in Section 3 below.

C.

1. As-Built Documentation: As part of the Communications System As-built documentation, include:

For each location, drawings of all IDS System equipment elements as located on poles, in cabinets,
2. power cabling, data communications cabling.

3.

IDS equipment configuration settings.

1.06

All witnessed (and signed by VTA) test sheets with procedures.

MEASUREMENT AND PAYMENT

A. Measurement: Intrusion Detection System must be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for Intrusion Detection System must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in this Section complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by VTA, and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Overview:

1. The Contractor must furnish, install, terminate, configure and test all IDS equipment specified under this project; as shown on the Contractual drawings; and to make a complete and fully functional system.

2. If necessary, the contractor must furnish and install miscellaneous wiring, mounting and IDS components not specifically outlined by these specifications to provide for a complete and fully functional IDS system.

3. The description below outlines IDS equipment specific requirements. Refer to all corresponding specifications within Division 26, Electrical and Division 27, Communications, for products and installation requirements for general wiring, power wiring, GRS and PVC conduits, fittings, trenching, supports, protection equipment, terminal blocks, junction boxes, pullboxes, and other accessories.

2.02 DESIGN REQUIREMENTS

A. IDS Sensors (IDSS) Assembly:

1. The IDS Sensors must include the following sensors:

   a. Light Detection and Ranging (LIDAR) laser sensors.

   b. Beam Sensors.

   c. Infrared Cameras (specified under section 28 20 00, Video Surveillance (CCTV).

2. The system must include system software and electronics provided for each sensor to generate discrete I/O contact closures, to generate the alarms and responses.

3. PLC logic and/or logic must be provided by the Contractor for input by VTA into the CCS, to analyze the various alarms and separate trains and intruder for identification purposes.

4. The design must be such as to prevent reversed assembly or improper installation of connectors, fastener, etc. Each item of equipment must be designed to protect personnel from exposure to high voltage during equipment operation, adjustments and maintenance.

5. The laser intrusion system must consist of all necessary mechanical hardware components, electrical and communication hardware and operating software, mounting brackets and weather protection enclosures required for continuous twenty-four hour a day operation outdoors in a harsh outdoor transit environment.

6. Environmental Operating Conditions: The equipment must meet all its specified operating requirements after subjecting to any combination of the following:

   a. Ambient temperature range of -30 degrees to +50 degrees Celsius.

   b. Relative humidity from 5 to 95%, non-condensing.

   c. Vibration fatigue limits according to IEC 68 part 2-6.

   d. Rain and snow.

Functional Characteristics: The intrusion detection system must be able to detect human intruders and other objects under any weather conditions. The system detection and segregation algorithms will produce an alarm when an intruder is detected but will not alarm if animals, debris or other foreign objects enter the monitored field, along with Trains.

7. Provide and integrate logic detection algorithms to analyze and segment the alarm data for cluster identification specifically to distinguish an intruder from a train and detect an intruder trying to enter the Intrusion Detection area by walking next to a moving train.

8.

2.03 LIDAR SENSOR

A. The LIDAR Sensor must perform the following functions:

1. Detect targets walking, running or crawling on hands and knees: 1 square foot prone crawling person or 12 inch sphere, without the need for reflectors or other marking.
2. Target velocity: 0.2 ft. to 30 ft/sec.
3. Probability of detection 99%.
4. False alarm rates less than 5%.
5. Small animals and debris must not trigger an intrusion alarm.
6. Detection range: width of 140 meters, length of 80 meters with 10% reflectivity.

B. The LIDAR Sensor has the following features:

1. Scanning Angular Resolution of 1 degree to 0.167 degrees.
2. Scanning time no more than 26 msec per scan.
3. Measurement Resolution of 10mm and system total error of 35mm.
4. Range: Max. 80 m.
5. Data Interface: Ethernet.
6. Switching outputs: dry contact closure or 24 VDC output.
7. Supply voltage: 24 VDC.
8. Enclosure Rating: IP 65 and IP 67 (NEMA 4 and NEMA 6).
9. Vibration: according to IEC 68 part 2-6. EN 60068-2-6 (1995-04)
10. Interference Electrostatic: according to IEC 801, part 2-4.
11. Operating Ambient Temp: -30 to + 50 degrees C.
12. The LIDAR sensor must be rated laser protection class 1 (eye-safe) and must comply with electrical interference (electrostatic discharge) regulations IEC 801, part2-4.
13. Wire/Cables: As recommended by the manufacturer.

C. Communication with the Lidar Sensor for the purpose of calibration must be via hard-wired communication lines. Data transfer between the laser scanner and external PC for calibration purpose must be via 10/100/1000BASE-X ethernet interface.

D. One LIDAR Sensors must be provided for each IDS location.

E. Mounting Bracket and Weather Shield Mounting brackets and hardware must be provided to allow mounting of the laser scanner to OCS poles. The mounting brackets must have adjustments to allow the scanner to be rotated and adjusted.

F. Appropriate weather hood is to be provided to prevent continuous exposure of the scanner's front window to direct sunlight and rain for outdoor installations.

G. The LIDAR Sensor must be the Q-Guard manufactured by Quarnergy, LMS-511 manufactured by SICK (Germany) updated for transit applications, or approved equal.

2.04 BEAM SENSOR

A. Provide 3 sets of beam sensors per IDS location

B. Beam sensor must be photocell type dual beam sensor, with transmitter and receiver.

C. Range up to 30 m

D. Selectable response time

E. Operating temperature: -13 degrees F to 131 degrees F

F. IP 55 rating

G. Dimensions: Approximately 3" x 3" x 7"

H. 10.5 VDC to 28 VDC power

I. Suitable to mount on 4x4x1/4" galvanized steel pole, or concrete wall.

J. Operating Temperature:

K. The Beam Sensor TX/RX pair must be Bosch ISC-FPB1-W30Ds or approved equal.

2.05 IDS CCTV CAMERAS:

A. The Infrared IDS Cameras are specified under Section 28 20 00 "Video Surveillance (CCTV)".

2.06 VISUAL ALARM

A. Upon any alarm from any IDS device, the strobe actuates via interposing relay contact output from SCADA Remote I/O unit.

B. Provide 1 visual alarm per IDS location

C. The visual alarm must be a strobe light, in color selected by VTA, mounted above the IDS cabinet, on the OCS pole.

2.07 AUDIBLE ALARM

A. Upon any alarm from any IDS device, the audible alarm actuates via interposing relay contact output from SCADA Remote I/O unit

B. Provide 1 audible alarm per IDS location.

C. The alarm must be a public address type speaker, with remotely programmable fixed message.

D. The audible alarm must be mounted just below strobe light, above the IDS cabinet, on the OCS pole.

2.08 IDS CABINET:

A. The IDS Cabinet is specified under section 27 11 16 “Communications Cabinets, Racks, Frames and Enclosures”.

2.09 INTERFACE

A. Communications Interface:

1. The Intrusion Detection System must interface using the dry contacts with the corresponding IDS a Remote I/O unit and station SCADA PAC described in Section 28 40 00, “SCADA Monitoring and Control System” of these technical specifications. The Intrusion Detection System must pass to the SCADA the Intrusion alarms via the Intrusion Detection cabinets.

2. The Intrusion Detection System CCTV Cameras must interface the corresponding IT Edge Switches located inside the IT IDS Cabinet for ethernet POE/Video, and to the SCADA Remote I/O unit for discrete alarms from the cameras. The Intrusion Detection System Cameras must pass video information to the station CCTV DVR and, if necessary, be accessed remotely from the VTA CCTV Head-End Sever/Client workstations at the VTA Administrative Facility. The Infrared Cameras will also provide discrete alarm points to be provided to the IDS Remote I/O unit.

2.10 PHYSICAL

A. Mounting:

1. The IDS Cabinets, IDS Infrared CCTV Cameras, IDS Sensors must be pole-mounted or as shown on the Contract drawings.

2. Intrusion Detection cabinets: The IDS Sensors and IDS CCTV must interface for power and communications to the Intrusion Detection cabinets as shown on the Contract Drawings.

3. Other physical design information related to raceways, cabinets, racks, patch panels, terminal blocks is specified in the Section 27 05 00, “Common Work Results for Communications”, Section 27 05 28, “Pathways for Communications Systems”, Section 27 11 16, “Communications Cabinets, Racks, Frames and Enclosures” and Section 27 11 19, “Communications Terminal Blocks and Patch Panels.”

B. Terminal Blocks and Wiring:

1. The terminal blocks must be stationary within the enclosure and not mounted on swing-racks or doors.

2. Each terminal block and each terminal must be uniquely identified and readable by the maintenance personnel.

AC power wiring must be terminated on double row terminal blocks. All terminals to which the primary AC voltage is connected must be provided with protective covers and be sized to accept #10 AWG power wire as a minimum.

All wire connections between any moving part such as a swinging door and a stationary part or object must be stranded wire. All wiring must be of suitable gauge and insulation to meet the intended use.
3. The installation of this wiring must be such that no tension is exerted when moving parts are exercised.

Power wiring must be kept physically separate from communication/signaling wiring. Internal wiring
4. must be installed in wire harnesses or wire duct.

Wires and cables, both signal and power, must be color coded and labeled for identification. All wire and cable connectors and terminations must be permanently labeled for identification and must be
5. mechanically keyed to prevent improper connection. All connection points for external cables and wires must be easily accessible for connection / disconnection and must be permanently labeled. Prior
6. to implementation, the Contractor must submit for approval the proposed labeling scheme and the samples of the proposed labels.

The Contractor must submit Fiber Optic Loss Budget calculations for all fiber optic elements involved in the system.

7.

All wires must be appropriately terminated by cable connectors, or on screw terminals using lugs, or
8. as recommended by the manufacturer. Isolated wire terminations (i.e., not connected by one of these methods) using solder will not be accepted.

2.11 POWER SUBSYSTEM

A. Source:

1.

The SCADA IDS Cabinet must derive 208 VAC or 480 VAC power from the adjacent passenger stations as shown on the Contract Drawings and as directed by VTA. The contractor must provide a 480 VAC/208VA step down transformer as necessary, in a separate enclosure, preferably above the SCADA IDS enclosure, but may be mounted below it. The IT IDS enclosure shall derive UPS power
2. from the SCADA IDS enclosure.

B. The IDS CCTV cameras must derive 24 VAC power from the adjacent IDS cabinet. The IT IDS IP switch shall derive power from the SCADA IDS enclosure UPS.

2.12 The Contractor must submit for approval voltage drop, conduit fill ratio and loads calculations showing
A. adequate size of all required power system components and wiring.

B. MAINTAINABILITY

C. Maintenance Safety: The IDS equipment must be designed, configured, and installed to optimize the safety of maintenance personnel.

D.

1. Self-Tests: All IDS Equipment components must perform self-tests upon power on and upon command from the Central to verify that the equipment is in operational state.

Fault Detection and Reporting: Faults must be indicated to the Field Replaceable Unit level:

Equipment Replacement:

The IDS Equipment must provide a safe means for maintenance personnel to disable power to the equipment under maintenance. The power-disabled state must be indicated locally.

The IDS must provide for safe modules replacement. Upon replacement and power-up, the equipment self-tests must automatically be initiated. Self-testing must include verification that the configuration of the replaced modules matches the previous configuration.

IDS EQUIPMENT PROGRAMMING AND MANAGEMENT

2. The Contractor must ensure the provided IDS equipment's physical and software interface is compatible with the existing VTA IDS field and head-end equipment programming.

2.13

A. The Intrusion Detection Equipment alarm indications must be terminated at the station SCADA Remote I/O units. The Contractor must implement all necessary termination, configuration and software changes to the PACs and the SCADA to provide for a fully functional and integrated Intrusion Detection System.

B. The Intrusion Detection Equipment CCTV images and video must interface with the adjacent station CCTV DVRs via the IT Edge Switch Ethernet LAN. The IDS CCTV images and video must be stored at the station DVRs similar to the images and video from the station CCTV cameras. The playback of the stored

C. and live IDS CCTV data must be accessible to the authorized users from the VROF facility. The Contractor must implement all necessary termination, configuration and software changes to the IDS LAN Switches and the CCTV system head-end to provide for a fully functional and integrated Intrusion Detection System. CCTV images from IT CCTV cameras must interface with the VROF CCTV software. The CCTV images from the SCADA infrared sensor CCTV cameras must interface with either the VROF CCTV software, or separate IDS CCTV software.

2.14 **ENVIRONMENTAL**

A. All CCTV System components must operate continuously with specified performance and without reduction in equipment life under the conditions specified in Section 27 05 00 "Common Work Results for Communications" and Section 28 20 00, "Video Surveillance (CCTV)."

PART 3 -

EXECUTION

3.01

A.

FACTORY TESTS

3.02

The Contractor must perform tests to verify the data communications for all IDS Equipment.

A.

INSTALLATION – GENERAL

B.

The IDS Equipment must be mounted in locations least susceptible to damage and/or vandalism. Install all

C. components to provide aesthetically pleasing results. Coordinate the actual locations of all visible components in advance with the VTA.

D. All equipment installations must be in compliance with the specifications, contractual drawings, applicable codes, and manufacturer recommendations.

The Contractor must inspect and test all supplied equipment at time of delivery to the construction site to assure that no damage was done in shipping and that the specified equipment was received. A copy of these inspection reports must be submitted to VTA.

Prior to delivery to the site for actual installation, shop-assemble and test all devices. Fully test and demonstrate that each is a correctly working device.

E. The Contractor is responsible for all necessary programming of the IDS equipment to make a fully functional IDS system. This also includes installation of all applicable software patches and firmware upgrades.

F. Installation Test Procedures: Installation and test of the IDS equipment must be conducted according to the approved Installation Plan and Field Test Procedures. The IDS Equipment installation must not commence prior to VTA approval of the Installation Plan for each corresponding type of the equipment installation.

G. Installation of the IDS Equipment: Installation and testing of the IDS equipment must include the following activities:

   1. Pre-installation/test inspection of available space and power, grounding system, cable runs and/or conduits, device terminal blocks, documentation on device terminal block wiring and testing performed by others.

   2. Confirmation of the physical inventory data and pre-installation visual inspection of IDS equipment.

   3. Post installation inspection of all equipment, mounting, cabling, and wiring.

H. Testing of Installed IDS Equipment: Records must be maintained for all IDS Equipment installation and test activities, and must be delivered to the VTA. Tests must include as a minimum:

   1. Equipment diagnostics.

   2. Data communications testing for communications between the IDS equipment and the SCADA.

   3. Device and alarm testing using the local test sets and end-to-end to the SCADA screens. See also Section 27 26 00, “Communications Programming and Integration Services” for the details of the SCADA head-end modifications.

   4. IDS CCTV live and stored video/images testing using the local test sets and end-to-end to the River Oaks CCTV client screens. See also Section 28 20 00, “Video Surveillance (CCTV)” for the CCTV cameras and CCTV System implementation and programming.

I. All copper power and signal wiring leaving/entering communication rooms, cabinets, and IDS equipment housings must be equipped with surge suppressors. Surge suppressors must be designed to prevent damage to IDS, SCADA and related equipment from power surges and transient voltages caused by lightning and other environmental factors.

J. Any existing equipment damaged during the course of the project must be substituted by the Contractor without any additional charge to VTA.

3.03 IDS EQUIPMENT INSTALLATION AND TEST

A. Install and configure the IDS equipment as per the manufacturer recommendations.

B. After the IDS equipment has been installed, configured and tested, the Contractor must submit the IDS equipment configuration spreadsheet with all pertinent settings.

C. Any modifications to the specified mounting details must be approved by the VTA. Paint all IDS equipment mount, enclosures, conduits to conform to paint color selected by the VTA.

D. All connections to the IDS components must be plug connectorized to facilitate quick removal and replacement of the equipment.

The Contractor must install, terminate, and test all cables employing qualified personnel. The foreman for any cable-pulling task must have a minimum of two years' experience in the pulling of cables through conduit/duct systems. All cables must be hand-inspected to ensure no physical defects as the cable is installed.

Technicians performing cable installation, termination, and testing must have been trained and certified in the tasks assigned to them. This training must have been in an industry recognized training course and the technicians must be certified to have successfully completed the entire course of study.

Terminations for unshielded twisted pair cabling must be performed with the proper tools for terminating Category 6 RJ-45 connectors in accordance with TIA/EIA 568.

There must be no field connector termination for the fiber-optic cables. The Contractor must utilize manufacture pre-maid fan-out kits and pigtails (with already terminated connector) to be fusion spliced with the incoming fiber optic cables. All fiber-optic terminations must be performed with the tools specifically designed for such purpose.

The Contractor must install wires and cables in accordance with the Cable Manufacturers' recommendations.

The Contractor must establish the maximum allowable length of cable that may be safely pulled into each conduit after obtaining the Wire and Cable Manufacturer's recommendations regarding pulling limits for the cables. If the pulling tension for any cable exceeds the maximum allowable, that cable must be removed and replaced with new cable.

Where feasible, pulling tensions must be calculated by the Contractor from both directions to determine which will be easier and result in less pulling tension on the cable. The lower tension direction must be utilized. All fiber-optic cables must be installed within protective inner ducts.

Suitable pulling apparatus in good working condition must be used. The Contractor must demonstrate the operation of the pulling apparatus for the VTA's approval. It must be provided with a smooth variable speed control for pulling. For plastic conduit, either stranded steel or a manila hemp pulling line must be used. Nylon line must not be used due to its elongation under tension. A dynamometer to measure the pulling tensions must be used by the Contractor at the pulling end of the installation and the measured value must be recorded for each pull.

Proper procedures for feeding cable into the conduit must be established by the Contractor. Feed-in tubes, sheaves, cable reel jacks, and other appropriate tools necessary to provide proper bending radii and minimal friction during installation must be used. Direction or training of the cables on entering and exiting the conduit must coincide with other parts of the installation arrangement so that the cable is not damaged or over-stressed.

The Contractor must use only the Wire and Cable Manufacturer's approved pulling compound or lubricant compatible with the cable. The lubricant must be used in ample quantity to reduce friction and applied in
1. such a manner that the cable is lubricated throughout the entire length being pulled through the conduit. The lubricant must be non-hygroscopic and vermin-proof.

2.

The installation must be in accordance with the Contractor's approved written procedure and check-off list that must include the following considerations:

Spare wires and cables must be installed at the same time that the active wires and cables are being installed.

The cables must not be pulled through manholes.

If it becomes necessary to remove a cable from a conduit, all cables in that conduit must be removed. Cable removed from conduit must not be reinstalled or used elsewhere.

Two-way communication between pulling and feed ends must be established before and during the installation.

3. Crossovers and kinks must be avoided at feed end.

4. Cable must be protected after installation and prior to terminating or splicing.

5. After pulling, the tension end of the cable damaged in the pulling process must be cut off.

6. All cables must be identified.

7. The cable installation in manholes and pull boxes must not interfere with the future use of or access to unused conduit.

8.

9.

E. Splices will not be permitted in cables. Cables must be continuous between all designed termination points. Splices at certain junction box locations may be allowed at the discretion of the VTA. Make recommendations for splices at such points to the VTA and obtain written approval to proceed.

Where splices are allowed, join the wire with crimped soldered connection, not wire nuts, and then cover with approved waterproof splice kits, such as heat shrink insulation or resin kits for fiber in an appropriate manner to ensure mechanical, electrical and waterproof integrity.

All splicing locations and materials must be approved by the VTA.

F. The Contractor must comply with the requirements of this Section for wire and cable identification.

All wires and cables must be identified whenever they enter or leave a junction box, manhole, housing, or enclosure, and at all terminations.

Permanent non-conducting marking tags fastened securely to the wires and cables must be used for identification.

Wire designations must consistently conform to an overall scheme prepared by the Contractor and approved by the VTA to indicate location, circuit, device, wire number, terminal branch, position, etc. Letters and numbers must be used.

A unique identifier must be assigned to, and marked on each cable to serve as a link to the cable record. Both ends of each cable and each cable wire and all single wires that terminate in equipment cabinets, equipment terminal blocks, punch down blocks and computers must be permanently identified with a tag. Tags must not obscure connection links used between terminal binding posts. Tags must be installed so that they may be read with a minimum of disturbance of the tags.

Sleeve Type Tags – tags for identification of individual cable conductors and field-installed wires within equipment cabinets must be the sleeve type as manufactured by Raychem Corporation, Thermofit Marker System (TMS) or approved equal. The application of the conductor nomenclature must be in accordance with the manufacturer's instructions and must result in a permanently bonded and legible identification.

Flat Plastic Tags – tags for identification of multi-pair or multi-conductor cables must be the flat plastic laminated types.

Tags must be one and one-half inches long by three-quarter inch wide with one, five-sixteenth inch hole located in the center of the width. The untreated tag must be milk white "vinylite", or approved equal.

The identifying nomenclature space must allow for three rows of lettering, and the tag material must be capable of receiving typed-on characters by conventional means. The height of the lettering must not be less than one-eighth inch.

After lettering, both the face and back side of the tag must be covered with a clear plastic coating, "vinylite", or approved equal. Spare wires for future use must be labeled, with exposed ends taped.

3.04 IDS CONTROL CABINETS INSTALLATION AND TEST

A. The Contractor must install, wire and ground the IDS Sensor Control cabinets as per the manufacturer recommendations. The actual locations of the cabinets must be approved by the VTA.

B. Grounding must meet the requirements and practices of applicable local, state, and federal codes for the specific cabling system they protect. Additionally, all telecommunications grounding/bonding must conform to TIA/EIA-607 requirements.

3.05 MISCELLANEOUS

A. Provide, install and test all necessary miscellaneous wiring, mounting and IDS System components not specifically outlined within these specifications to provide for the complete functional IDS system.

3.06 TEST AND MAINTENANCE EQUIPMENT

A. The Contractor must provide sufficient test equipment to verify the requirements of these Technical Specifications.

3.07 SYSTEM TESTING

A. After the system is completely installed in accordance with the Specifications, Drawings, and Details, Contractor must conduct a full systems test. Provide a copy of the record of results to the VTA. Use the test procedures submitted as approved by VTA, to test and evaluate the system. These tests must be part of the overall Final System Acceptance Testing requirements. All tests must be performed and signed off for each device in the system.

B. Following the installation, the Contractor must inspect the equipment to verify that all hardware is installed in its proper location, marked for identification, and all wiring is properly terminated and labeled.

C. Ensure that the entire IDS System is free of ground loop problems. Test for and remove any ground loop problems in the IDS System at no additional cost to VTA.

The Contractor must verify that electrical, environmental, and mechanical specifications for all installed equipment are appropriate and compliant with all codes for each location in which it is installed prior to installation, and include verification of readiness.

A test procedure for all copper and fiber cable installed must be prepared by the Contractor and supplied to the VTA for review and approval.

Local area network cabling: The procedure must include the use of a Category 6 cable tester capable of testing unshielded twisted pair up to a minimum of 1 GHz frequency. Tests must be performed in accordance with TIA/EIA 568 and the cable test set instructions. The procedure must also include use of the fiber-optic OTDR and other test equipment to verify optical interfaces and record optical losses.

An electronic copy of all test reports containing the results of all measurements must be submitted to the VTA for approval. The test equipment manufacturer's instructions for operation and electrical connections must be followed.

Copper cables must be tested for continuity, loop resistance, insulation resistance, shield continuity, cross talk, and impedance. Tests must be performed in accordance with the tests for each installed cable run must be performed and recorded on electronic media by the Contractor.

Fiber cables must be tested for continuity and optical losses for all active and passive fiber-optic components. The optical transmitting and receiving power must be within the manufacturer recommended range for the corresponding fiber-optic transmitting devices. The optical losses at the fiber connector must not exceed 0.75 dB. The optical losses at the fiber splice must not exceed 0.3 dB.

Following installation, the Contractor must conduct a VTA witnessed test to verify the system parameters.

VTA must be given 15 days advance notice of the date the installation will be ready for final testing so that VTA may witness the tests, if it so elects.

D. All tests must be performed and signed off for each IDS device in the system:

1. Coverage:

   a. Verify IDS Sensor coverage areas are achieved as approved by VTA.

   b. Verify IDS CCTV coverage areas are achieved as approved by VTA. Conduct additional IDS CCTV tests to conform installation and testing requirements for the CCTV cameras as outlined in the Section 28 20 00, "Video Surveillance (CCTV)" for the CCTV cameras and CCTV System.

2. Alarm outputs for each track.

3. Power Supply Characteristics: Output voltages, protective features, etc.

4. Verify proper integrated operation of all IDS Sensor elements, including LIDAR Sensors, Beam Sensors, and Infrared Cameras Sensors to the Remote I/O unit and local (laptop).

5. Verify proper integrated operation of all IDS CCTV elements, including IDS CCTV Camera and IT Edge Switch.

3.08 FIELD QUALITY CONTROL

A. Quality: The quality of the Communications System installation must be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications and workmanship standards and practices.

END OF SECTION

SECTION 28 40 00

SCADA MONITORING AND CONTROL SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes requirements for the SCADA Monitoring and Control Systems to be installed for Passenger Stations Communications Node Programmable Automation Controllers (PAC) in Signal/Communications Rooms, and SCADA Remote I/O Units for each station Elevator Interface, station Mechanical Equipment, Intrusion Detection System, and Signal Cases (security). The following equipment interfaces with either an ethernet interface or SNMP (to OCC CCS directly), or discrete input/output points hardwired to SCADA PAC or Remote I/O units:

1. SCADA PAC - Interfaces directly via form C dry contacts (monitoring), interposing relay outputs (controls), or telemetry:
    a. Seismic Detectors
    b. Station ancillary room door contacts
    c. Station power metering (telemetry)
    d. Public Address System Monitoring
    e. Emergency Telephone System Monitoring
    f. Communications room security door contacts
    g. Emergency Telephone off hook/pushbutton status (Elevators, Platforms)
    h. Station Mechanical Equipment (discrete I/O type and Bacnet interface)
    i. Smoke Detectors/Fire Alarm Control Panel/Emergency Management Panel
    j. Emergency Lighting Battery/UPS
    k. Normal Lighting, Solar Powered Lighting
    l. Traffic Controller
2. Signal System Interfaces – Through Communications Hub (Serial Device Server)
    a. Vital Processor Interface/CTP Train Control
    b. Signal Monitoring Unit (SMU) (download dump)
    c. Train to Wayside Communications (TWC Loops)
3. TES TPSS PAC - Interfaces directly via form C dry contacts (monitoring), interposing relay outputs (controls), or telemetry:
    a. Traction Power Substations and TES Pad Mounted Disconnects (direct to OCC CCS)

4. SCADA Remote I/O Units – Interfaces directly via form C dry contacts (monitoring), and interposing relay outputs (controls):

   a. Station Elevators

   b. Intrusion Detection System sensors

   c. Signal Case door contacts

   d. TES OCS Manual Operated Disconnects (MOD)

5. Interface to other subsystem PLCs shown on mechanical and station lighting drawings (through single ethernet interfaces):

   a. Station Mechanical Equipment (ethernet type)

   b. Station Lighting Controller (Data Enabler, normal and accent lighting, through IT network interface)

6. Interfaces to other subsystems via SNMP to CCS or separate OCC application, directly to the OCC CCS:

   a. Environmental (temperature/humidity) and Security Monitoring Units (ESMU) (CSS)

   b. Uninterruptible Power Supply (UPS) monitoring (CSS)

   c. Power Distribution Units (Separate Application)

B. The SCADA equipment consists of:

1. Programmable Automation Controllers (PAC)

2. Industrial Managed Ethernet Switches

3. Interface modules

4. Input/output devices

5. SCADA Software

1.02 RELATED SECTIONS

A. Section 27 05 00, Common Work Results for Communications

B. Section 27 05 28,Pathways for Communications Systems

C. Section 27 11 16,Communications Cabinets, Racks, Frames and Enclosures

D. Section 27 11 19, Communications Terminal Blocks and Patch Panels

E. Section 27 13 00, Communications Network Cabling

F. Section 27 15 00, Communications Low-Voltage Conductors and Cables

G. Section 27 21 00, Communications Network Equipment

H. Section 27 26 00, Communications Programming and Integration Services

I. Section 27 30 00, Telephone System

J. Section 27 42 19, Public Address System

K. Section 27 42 20, Passenger Information Monitor System

L. Section 28 20 00, Video Surveillance (CCTV)

M. Section 28 31 00, Intrusion Detection System (IDS)

N. Section 34 54 00, Automated Fare Collection System

1.03 REFERENCED STANDARDS

A. The latest versions of the following standards and references apply to the work included in this Section, in addition to those codes and standards common to all communications subsystems specified in section 27 05 00, Common Work Results for Communications. If a conflict must arise between various standards, the California state code amendments must govern, or the most strict/conservative requirement must govern.

B. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

1. C37.1 — Standard Definition, Specification and Analysis of System Used for Supervisory Control, Data Acquisition and Automatic Control.

2. C37.90.1 — Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems.

3. 730 — Standard for Software Quality Assurance Plans.

4. 730.1 — Software Quality Assurance Plans.

C. The International Society for Measurement and Control (ISA):

1. RP55.1 — Hardware Testing of Digital Process Computers.

D. Underwriters Laboratories Inc. (UL):

1. 508 — Industrial Control Equipment.

E. Open DeviceNet Vendors Association (ODVA):

1. The Specification for EtherNet/IP™

2. The Specification for DeviceNet™

F. International Electrotechnical Commission (IEC):

1. IEC 61131 — Programmable Logic Controllers

2. IEC 61158 — Digital Data Communications for Measurement and Control – Field Bus for Use in Industrial Control Systems

3. IEC 61784 — Digital Data Communications for Measurement and Control

1.04 QUALITY ASSURANCE

A. Software Quality Assurance: The Contractor must plan, implement, administer, and maintain a comprehensive software quality assurance program, conforming to IEEE 730 and IEEE 730.1, for PLC software.

B. Emissions: PACs, PAC Test Sets and any other active devices must comply with FCC emissions regulations for class A computing devices.

C. Device Interface Management Database: A device interface management database must be developed and provided to the VTA. The database must define each I/O point for each PAC, the terminal block terminal for each I/O point, and the precise path between terminal block connectors and PLC, including I/O card and chassis. The database must be verified during installation and test, and must be provided to the VTA in electronic digital format and hardcopy format. Electronic digital data must be either flat files, or database files of a commercially available relational database product which operates in the Windows environment to be agreed between the VTA and the Contractor.

1.05 SUBMITTALS

A. Software Quality Assurance Plan.

1. Submit a Software Quality Assurance Plan for PAC software.

B. Software Requirements Specification.

1. The Contractor must submit a PAC Software Requirement Specification (SRS), including description of the I/O logic and message-level interaction between the PAC and the CCS.

C. Design Information:

1. Conceptual Design Review: The Contractor must submit the following information as part of the CDR: separate block diagrams for TES substations and Communications Nodes.

2. Preliminary Design Reviews:

a. The Contractor must submit the following information as part of the Preliminary Hardware Design Review submittal:

1) Description of PAC configurations, with detailed block diagrams. I/O configurations for TES substations and for Communications Nodes must be included.

2) PAC equipment data sheets.

3) PAC performance analysis using manufacturer data or test data showing that the PACs meet the Response Time requirements developed in the Conceptual Design. Note that this analysis must consider system poll time as part of the overall Response Time.

4) PAC equipment reliability analysis including the MTBF for typical Communications and TES substation PACs.

b. The Contractor must submit the PAC Preliminary Software Design Review submittal package. This must include:

1) Preliminary Software Design Description.

2) Preliminary version of the Device Interface Management Database. This version must include a list of each I/O point for each PAC.

3) Other software design information required by Section 27 05 00, Common Work Results for Communications.

Final Design Review information: The Contractor must submit the following information:

As part of the Software Detailed Design Review submittal - Fully commented Ladder or Boolean based logic source code; description of memory layouts and register usage; software module design for software implemented in "C" or similar functional language; the Device Interface Management Database.

3.

a. As part of the Hardware Final Design Review submittal - Detailed cable drawings, schematics and equipment and I/O wiring diagrams for each type of location (e.g., TES substation, Communications Node) where a PAC is located.

b. As-Built Documentation: As part of the Communications System As-built documentation, include:

For each PAC, drawings of all PAC equipment as located in cabinets, power cabling, data
D. communications cabling to the CTS, and I/O subsystem wiring and cabling.

1.

Final Ladder or Boolean based logic source code for each PAC; memory layouts and register usage for each PAC.

2.

The Device Interface Management Database, including complete instructions on using and
3. maintaining the database.

1.06 MEASUREMENT AND PAYMENT

A. Measurement: SCADA Monitoring and Control System must be measured by the lump sum price as listed in the Schedule of Quantities and Prices.

B. Payment: The lump sum payment for SCADA Monitoring and Control System must include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in this Section complete in place, as shown on the drawings, as specified in these Technical Specifications, and as directed by VTA, and no additional compensation will be allowed therefore.

PART 2 -

2.01 PRODUCTS

A.

1. GENERAL REQUIREMENTS

System Description

a.

b. The new PAC (PLC) must be fully compatible with the legacy existing Allen-Bradley SLC 500 series equipment in order to facilitate PAC operations and maintenance. The Contractor may propose alternative equipment in accordance with the General Contractual Provisions. Any alternative equipment proposed must be:

Comply with Referenced Standards.

Perform functions and support I/O in a manner, which is fully compatible with the existing SCADA system and the established existing PAC's functionality, and existing software and communications protocols utilized at the OCC to received and send data.

c. Equipment family must have an installed base of at least 50,000 units (PAC/PLC or Remote I/O).

2. The SCADA System (SCADA) must consist of Programmable Automation Controllers (PACs or PLCs), interface modules, Ethernet Switches, Remote Input/Output (Remote I/O) equipment, software, and associated devices and wiring to provide for the monitoring and control of equipment being installed for the EBRC/Capitol LRT extension as indicated.

a. The PACs and associated equipment must be installed in the Story and Eastridge VTA Communications Rooms. The Remote I/O and associated equipment must be installed in the Station Mechanical Equipment Rooms, Equipment room adjacent to the Elevator Equipment Room, Electrical Equipment Room, SCADA Intrusion Detection Cabinets adjacent to Story Station and at both elevated guideway approaches near Alum Rock and Eastridge Stations, and at Signal Cases along the guideway.

b. The PACs must be programmed to interface with field equipment as described in this Technical Specifications Section and to monitor the status and alarms from this equipment. In some instances, the PACs must be programmed to send control commands to field equipment. Programming must not allow the generation of erroneous commands.

c. The PACs must be compatible with existing VTA SCADA equipment at the VROF.

d. The PACs must communicate with the monitoring and control equipment at the VTA Operations Control Central (OCC) and the VROF. The communications link must be through the Operations Access Switch in the SCADA Room and through the Optical Backbone Network Equipment as specified.

3. Systems and Equipment to be Monitored and Controlled by SCADA:

a. The relationship between SCADA and other systems and equipment must be such that no action or failure of SCADA must cause a failure of the system or equipment.

b. SCADA PAC - Interfaces directly via form C dry contacts (monitoring), interposing relay outputs (controls), or telemetry:

1) Seismic Detectors

a) Monitor and alarm to OCC.

b) Interface to Elevator control.

2) Station ancillary room door contacts

a) Intrusion detection.

3) Station power metering (telemetry)

a) Voltage.

b) Amperage.

c) Power metering

4) Public Address System Monitoring: SCADA must monitor and report Public Address system malfunction alarms to the VTA OCC, including:

a) Power Amplifier or PA Mixer alarms.

b) PA output wiring shunt or open conditions.

5) Emergency Telephone System Monitoring

a) Emergency Telephone off hook/pushbutton status.

6) Communications Room, TPSS, Signal Case, Equipment Rooms Intrusion Detection, door contacts

a) Intrusion detection.

7) Station Mechanical Equipment (discrete I/O type)

a) Sump high water alarm.

8) Smoke Detectors/Fire Alarm Control Panel/Emergency Management Panel: SCADA must monitor and report the status of the VTA Communications Room fire alarm panel to the VTA OCC.

a) Fire Alarm (red).

b) Trouble (yellow).

9) Emergency Lighting Battery/UPS

a) Battery Voltage.

b) Status (on/off).

10) Normal Lighting, Solar Powered Lighting

a) Battery Voltage.

b) Power consumption.

11) Traffic Controller (to existing Alum Rock PLC)

c.

a) Train approach/departure loop status.

Signal System Interfaces – Through Communications Hub (Serial Device Server)

1) Vital Programmable Logic Controller (VPLC).

d.

2) Signal Monitoring Unit (SMU) (download dump to OCC upon demand).

3) Train to Wayside Communications (TWC Loops).

SCADA Remote I/O Units – Interfaces directly via form C dry contacts (monitoring), and interposing relay outputs (controls):

1) Station Elevators, through SCADA ELS/IDF cabinet:

a) SCADA must report elevator alarms, position, movement, and occupancy as indicated to the existing VTA SCADA system at the Younger Maintenance Facility.

b) SCADA must provide elevator control as indicated from the existing VTA SCADA system at the VROF so that the POC elevator can be called to the top level, bottom level, or be shut down.

c) Interface with Seismic Sensor.

d) Emergency Telephone off hook/pushbutton status (or directly to PAC).

2) Intrusion Detection System sensors

a) IDS Trainway Lidar Sensors.

b) IDS Trainway Beam Sensors.

c) IDS Infrared Sensors (via contact outputs from CCTV Camera sensor).

d) Calculated alarms on 3 status above.

e) Station Platform Adjacent Trainway Passenger Intrusion (via contact outputs from CCTV Camera sensor).

3) Signal Case door contacts

a) Intrusion detection.

4) TES OCS Manual Operated Disconnects (MOD)

a) Voltage Presence Detection (discrete voltage sensing relay)

b) Switch open/close status

e. Interface to other subsystem PLCs provided by others (through single ethernet interfaces):

1) Station Mechanical Equipment (ethernet type)

a) HVAC system for signal/communications room

2) Station Lighting Controller (normal and accent lighting)

a) Control and monitoring of normal and accent light, solar battery interface

f. Interfaces to other subsystems via SNMP to CCS or separate OCC application, directly to the OCC CCS:

1) Communications and IT Network Equipment Status (Separate NMS Application)

a) SCADA Managed switches (Distribution, Access, Edge)

b) IT Managed switches (Distribution, Access, Edge) (Reports directly to VTA Administrative Facility)

2) Environmental (temperature/humidity) and Security Monitoring Units (ESMU) (CSS)

a) Communications Racks

b) Signal Case

c) IDS Enclosures

3) Uninterruptible Power Supply (UPS) monitoring (CSS)

a) Multiple UPS alarms

b) Multiple UPS status/trouble

4) Power Distribution Units (Separate Application)

a) Port control to reboot attached equipment

B. Overview:

1. Field device typical I/O points lists are shown in the Technical Appendix TA-A (TBD 95% Design). Lists of miscellaneous additional monitored devices are shown in Appendix TA-B (TBD 95% Design).

2. PACs must be self-contained units capable of collecting digital data through relay dry contacts, and providing control outputs with electrically isolated relay contacts.

3. PACs must be solid-state electronic units of programmable design with stand-alone restarting capability. A real-time operating system necessary for the PAC to boot and establish communications with the CCS, store, load, compile, and execute program logic modules must be resident in non-volatile memory.

4. The PACs must communicate to the CCS using the LAN/WAN service described in Section 27 21 00, “Data Communications Network Equipment" of these technical specifications.

5. A power failure restart indication must be reported to the CCS after recovery from a power failure so that any necessary initializing and down-loading may be initiated by the CCS.

2.02 DESIGN REQUIREMENTS

A. The SCADA system must be compatible with the existing VTA SCADA equipment at the OCC at the Younger Maintenance Facility.

B. SCADA must utilize commercially available industrial-grade computer equipment and peripheral devices from the same manufacturer. Custom equipment must be limited to special functions and interfaces.

C. Configuration data must be stored in non-volatile memory.

D. SCADA equipment must support continuous operation in the electromagnetic environment where the equipment is installed.

E. Provide for local control, initialization and troubleshooting with a local control panel or portable test equipment.

F. Provide for remote initialization and troubleshooting via the communications network.

G. SCADA must be modular in design to provide expansion of performance and capacity by adding subsystem modules.

H. Include hardware and software tools and documentation for reconfiguration and expansion.

I. Perform self-tests upon power up and on command from local test equipment and remotely. Self-test must also be capable of being performed by input/output subsystems and input/output cards.

J. System Operation:

1. SCADA equipment must normally function without operator intervention except for routine service.

SCADA equipment must perform orderly system start-up and shut-down as commanded by a system operator.

2. SCADA equipment must prevent unattended action such as energizing output circuits upon power-up and power-restore.

3. SCADA outputs must function as momentary contact closures with a time duration that is stable and adjustable.

4. Input and output signals must be electronically isolated from the SCADA equipment.

5. SCADA must generate outputs via relays. Transient suppression circuits must be appropriately specified for the operating conditions. Contact ratings must be specified as required for the circuit.

6. SCADA interface relays and relay contacts must have an MTBF, at rated loads, of 5,000,000 cycles or more.

7. SCADA must automatically detect equipment failures and provide corresponding failure indications and auto-changeover of failed non-vital components, including peripheral devices and communications interface equipment while the system continues to operate.

8. Communications between VTA SCADA system at the VROF must utilize approved industry standard protocols, which support error detection and message transmission.

9. Wiring: SCADA must be designed and implemented so that wiring and cabling between the SCADA equipment and field devices are uniform in type, routing, and connection locations. The following interface requirements must be met:

    a. Discrete I/O signals to/from SCADA at each facility must terminate at one centralized location, the SCADA Termination Panel.

    b. SCADA terminations must include test points and rapid disconnects.

    c. All wires and cable must be labeled using a logically consistent labeling convention.

10. SCADA equipment must be protected from electromagnetic interference levels consistent with their locations. Bus bars of appropriate sizes must be provided for grounding in all input/output termination cabinets.

K. Response Time:

1. An alarm or device change of state must be displayed at the VTA OCC no more than 2.5 seconds after the event is reported to the local SCADA equipment.

2. When a user enters a command for any individual device or equipment control from the VTA OCC, the local SCADA equipment must generate the associated output signal, in the field, in no more than 2.5 seconds.

3. When a user requests a display, the completed display must appear on the screen in no more than 2 seconds.

L. Expandability:

1. I/O Expansion: SCADA must accommodate a 50 percent increase in discrete inputs and outputs as well as communications based I/O.

2. Network Expansion: SCADA must accommodate a minimum of one additional Ethernet connection at each Programmable Automation Controller (PAC) and Remote I/O location.

M. Maintainability:

1. SCADA equipment must be installed to allow easy maintenance access. All SCADA equipment must be accessible without removing other equipment in the cabinet/rack.

2. Tools required for replacement of faulty equipment must permit easy assembly/disassembly.

3. Removable/switchable terminal blocks must be used, so each side of the terminal block can be isolated from the other for I/O circuit troubleshooting.

N. Identification:

1. Provide module faceplates with color-coded, slip-in labels.

2. The outside label must feature both color-coding for module designation and labeling space for I/O point identification. The inside label must feature a detailed wiring or network diagram complete with the module catalog number and description.

3. All major assemblies and sub-assemblies, circuit boards, and devices must be identified using permanent labels or markings, each of which must indicate the manufacturer's catalog number and a product manufacturing date code.

O. Power: SCADA PAC and Remote I/O equipment must operate from 120 VAC (Communications room and IDS) or 24 VDC (TPSS) through dedicated circuits.

P. Processor and Real Time Operating System and Logic Functions:

1. Real Time Operating System and Logic functions must be implemented to receive data from and transmit data to the Station LAN (located at the Communications Node), perform address decoding and error checks, and transfer data to and from the point input/output logic. The Operating System must be the latest available version supported by the controller at the time of equipment installation.

2. In conjunction with the other PAC logic elements, the following functions must be performed:

   a. Respond to commands for retrieving data.

   b. Provide an acknowledge sequence for relay control commands. After a point is selected, a check must be made and an acknowledge message must be returned to the CCS. Acknowledgment of receipt and activation of the relay execute command must be determined by the action of the point under control.

   c. Prevent selection of more than one control point in a command sequence by:

      1) Inhibiting relays from inadvertently being energized during the initial power up period of the logic, as a result of failed communication, or any other anomaly.

      2) Protecting against a missing or failed logic card or assembly from causing an invalid operation, damage to other logic, or false transmission to the CCS.

      3) Protecting against power source over/under voltage conditions causing an invalid operation, damage to logic, or false transmissions to the CCS.

Q. Environmental: All PACs must operate continuously with specified performance and without reduction in equipment life under the conditions specified.

R. Components:

1. All electronic components must be mounted on plug-in printed circuit cards or modular subassemblies. All printed circuit boards of the same model number must be identical. Printed circuit boards must not include or require tack soldered components (i.e., not mounted in locations with plated through holes or in sockets) on the boards for "tuning" or "timing" purposes. Printed circuit cards and modules, which contain modifications accomplished by the removal of printed circuit lands and corrected with wired replacements, are not acceptable.

2. All interconnecting cables must have keyed housings or contact pins to ensure correct mating of connectors and prevent damage from improper connection. All connectors (on the PAC and cable) must be clearly marked for re-connection (P1-J1, P2-J2).

3. Each printed circuit card and subassembly must be model and serial numbered to uniquely identify it.

2.03 PROGRAMMABLE AUTOMATION CONTROLLERS

A. Provide chassis mounted Programmable Automation Controllers (PACs) that meet the following requirements:

1. Chassis:

a. Communications between modules must be through the chassis backplane.

b. No fans or other means of cooling (other than heat sinks) must be required for proper system operation.

c. All modules including the controller must be designed for insertion and removal from the chassis while under power without damaging the chassis or any module, including the module being inserted or removed.

d. The chassis must be sized to include at least two open slots for future I/O or communications modules.

e. Chassis must be cabinet/rack mounted unless otherwise indicated.

2. Power Supplies:

a. Provide redundant power supplies

b. Input voltage range of 85 Vac to 265 Vac

c. Input frequency ranges of 47 Hz to 63 Hz

d. Power must be from 120 Vac

e. Include all adaptors and cables required for connection to chassis

3. Controller Modules:

a. Chassis mounted

b. Handle a minimum of 32 concurrent tasks

c. Support multiple, concurrent scans

d. Support “change-of-state” inputs

e. Communicate with multiple remote I/O devices configured with multiple I/O modules

f. Support multiple interface modules in the same chassis including:

   1) EtherNet/IP interface modules

   2) DeviceNet interface modules

g. Eight MB minimum of non-volatile memory available for user program

h. Support non-volatile supplemental memory

i. Include removable non-volatile memory back-up (for both operating system and user program) through a secure digital (SD) card form of memory back-up with at least 1GB of memory.

j. Support both local and remote programming. Provide a secure means of locally selecting the “program” mode or the “run” mode

k. Include a built-in communication port – either RS-232 or USB 2.0 or later – usable for programming, firmware upgrades, and data monitoring

l. Perform internal diagnostic checking with visual indication of system status

m. Include visual controller status indications for controller mode ”Run” or “Program”, serial port activity, and power supply status

n. Support for full redundancy via addition of a second chassis and power supply.

4. Ethernet Adapter Modules:

   a. Chassis mounted

   b. Interface with equipment supporting EtherNet/IP

   c. Support the Ethernet/IP protocols

   d. 10/100 Mbps communication rate

   e. Support up to 128 TCP/IP Connections

   f. Include one USB port for local programming

5. I/O Modules must conform with the following requirements:

   a. Chassis mounted

   b. Support monitoring and control data that is passed between the associated equipment and SCADA

   c. Support a minimum of 16 points or as required to include 25 percent spare contacts

   d. Support a variety of voltages

   e. Include reverse polarity protection

f. Include adjustable input delay timer

B. The PACs and associated equipment must be comprised of the following:

1. Chassis: Allen-Bradley Model 1756-A10/B chassis, or larger as required to provide space for the necessary modules and future expansion, or equal
2. Power Supply: Allen-Bradley Model 1756-PA75R/A redundant power supply or equal
3. Controllers: Allen-Bradley ControlLogix 1756-L73 controller or equal
4. Ethernet Adapter Modules: Allen-Bradley Model 1756-EN2T Communications Interface Module or equal
5. I/O Modules:
   a. Digital Input Modules: Allen-Bradley Model 1756-IB16IF or equal
   b. Digital Output Modules: Allen-Bradley Model 1756-OB16IEF or equal

2.04 ETHERNET SWITCHES

A. Ports

1. Provide a total of at least 10 Ethernet ports, at least 2 of which can be provide through SFP modules.
2. Ethernet ports must be at least Fast Ethernet except for the SFP module ports which must be at least Gigabit Ethernet ports.

B. Software Features

1. Support IPV6
2. Support CIP (Common Industrial Protocol) port control
3. Support CIP clock synchronization (ODVA implementation of IEEE standard 1588)
4. DHCP per port IP address assignment capability
5. SNMP (Simple Network Management Protocol) management protocol
6. Encryption of administrative traffic
7. Support EtherNet/IP protocol
8. VLANs with trunking
9. IEEE standard 802.1x security for access control and authentication
10. Quality of Service (QoS) must be user selectable

C. Environmental

1. Operating Temperature Range – 0 degrees F to 140 degrees F
2. Vibration tolerance (operating) (per IEC 60068-2-6) – 2 g at 10 to 500 Hz

3. Shock tolerance (operating) (per IEC 60068-2-27) – 30 g

D. Industrial Managed Ethernet Switches must be Allen-Bradley Stratix 5700 number 1783-BMS10CGP or approved equal.

2.05 REMOTE INPUT/OUTPUT MODULES

A. Provide Remote Input/Output modules that meet the following requirements:

1. Power supplies:

a. DIN rail or rack/cabinet mounted

b. 120 Vac input - 24 Vdc output

c. Include all adaptors and cables required for connection to the integrated controller

B. The Remote I/O Units must be comprised of the following equipment.

1. The units must be Allen-Bradley Flex I/O 1974 series or equal

2. The power supplies must be Allen Bradley 1974-PS3 or equal

2.06 TERMINATION PANEL

A. The termination panels must be located as close as possible to the SCADA PACs. Where practical, the termination panels may be collocated in the rack with the SCADA PACs. Termination blocks must be easily accessible. Size the termination panel with a minimum of 50 percent spare contacts.

B. Terminal blocks:

1. Channel mounted, snap fit terminal blocks for 600 V service

2. Strap screw type for #22 thru #14 AWG

3. Nylon with barrier between circuits

4. Include vinyl marking strips for circuit identification

2.07 SOFTWARE

A. General Requirements:

1. Provide all software including operating systems, firmware, and applications necessary to design, configure, test, operate and maintain SCADA. This software must come with all required licenses, media and related documentation.

2. SCADA must provide diagnostic messages and system monitoring

3. SCADA must provide real time data

B. PAC Programming Software: The PAC programming software must be provided to VTA for installation on a workstation in the VTA SCADA Room at the Younger Maintenance Facility and must meet the following requirements:

1. IEC 61131-3 compliant
2. Support program development using relay ladder logic, structured text, functional block diagrams, and sequential function charts
3. Provide Graphical User Interface (GUI)
4. Support Controller configuration management
5. Support for modular development of programs
6. Produce human machine interface (HMI) screens
7. Provide graphic representations of the system architecture
8. Support system documentation
9. Support diagnostics and troubleshooting
10. The PAC programming software must be the Rockwell Automation RSLogix 5000 Enterprise Series Professional Edition or equal.

C. Network Configuration Software: The network configuration software must be provided to VTA for installation on a workstation in the VTA SCADA Room at the VROF and must provide configuration and diagnostics tools for EtherNet/IP communications modules. The network configuration software must meet the following requirements:

1. Support the EtherNet/IP standard
2. Support configuring devices using host names and IP addresses
3. View input and output data (for example, field wiring or voltage settings)
4. Establish multicast of inputs and peer-to-peer data for improved network efficiency
5. Define and configure chassis-based devices via graphical user interface
6. The SCADA network configuration software must be the Rockwell Automation RSNetWorx MD for EtherNet/IP Bundle or equal

2.08 ELEVATOR SEISMIC SENSOR SHUTDOWN SUBSYSTEM

A. Provide a seismic trigger as indicated to initiate immediate shutdown of all elevators at the Story Station pedestrian overcrossing in the event of a potentially damaging earthquake. The normally-open trigger contact must be wired to the SCADA system which, in turn, must transmit a shutdown command to each elevator. The seismic trigger must comply with the following requirements:

1. Actuating acceleration adjustable in the range of at least 0.025g to 0.25g
2. Response to accelerations with frequencies between 0.05 Hz and 15 Hz
3. Three independent relays for multiple alarm thresholds and power loss signaling
4. Respond to vertical, longitudinal and transverse accelerations
5. USB port for configuration and firmware updates

6. Bi-Color LED for visual indication of operation and diagnostics/self-test problems

7. The seismic trigger must be EQMet MitiGator+ IND or equal.

2.09 INTERFACE

A. Communications Interface: Communications facilities between the CCS and PACs must be provided under this Contract. The PAC must interface with the Station LAN Switch described in Section 27 21 00, "Data Communications Network Equipment" of these technical specifications.

B. PAC Communication Logic:

1. The PAC communication logic must perform the following functions:

    a. Error-check encode and decode.

    b. Decoding and processing of incoming messages.

    c. Assembling reply messages.

    d. Acknowledgement (i.e., resend/don't resend message).

2. The PAC must communicate using a 1000BASE-T/TX Ethernet port.

3. The PAC protocol must be compatible with the PAC, but transport must be TCP/IP in order to be compatible with the Station LAN and CCS.

4. The PAC must contain an SNMP agent necessary for the LAN manager to perform all required performance monitoring, configuration control and diagnostics. The agent must include all available manufacturer's MIBs which report the operating state or allow the remote configuration of the PAC equipment.

C. Communication Interface: The Contractor must provide the communication interface to the Station LAN Switch at the Communications Node. At each Communications Node, the physical interface connection to the LAN Switch must be either Ethernet 1000BASE-T (Communications PAC) or 1000BASE-LX (TPSS PAC).

D. Indication Inputs: The Contractor must provide input card modules for all input applications. Typical I/O points for PACs are listed in the Technical Appendix TA-A. Input card modules for each PAC must include spare points with the minimum number of spares equal to 25 percent of the PAC's input point count in Technical Appendices TA-A, or 8 spare points, whichever is greater.

E. Control Output Requirements: The Contractor must provide output card modules for all output applications. Typical I/O outputs are listed in the I/O List in the Technical Appendix TA-A. Output card modules for each PAC must include at least 4 spare points.

2.10 PHYSICAL

A. Mounting:

1. Communications Node: All PACs must be rack-mounted on Communications Node racks.

2. TES Substation: All PACs are provided and installed by the contractor on site at the TES Substation factory location, with the network interfaces and data transport to the station communications room rack by the Contractor. The Contractor must supply all accompanying equipment to include a SCADA enclosure for fiber distribution equipment, terminal blocks, and wire guides. Contractor equipment must be prepared for easy installation in the allotted space in the TPSS CIC cabinet. The TES substation supplier will wire the TPSS PAC to his equipment within the TPSS, and test the PAC functionality, supported by the contractor on-site at the TPSS manufacturing facility.

B. Terminal Blocks and Wiring:

1. Terminal blocks must be grouped by like point type within the Fiber Optic mounting enclosure. Each terminal block and each terminal must be uniquely identified and readable by the maintenance personnel.

2. AC and DC power wiring must be terminated on double row terminal blocks. All terminals to which the primary AC voltage is connected must be provided with protective covers and be sized to accept #14 AWG power wire.

3. Power wiring must be kept physically separate from communications wiring. Internal wiring must be installed in wire harnesses or wire duct.

4. Wires and cables, both signal and power, must be color coded and labeled for identification. All wire and cable connectors and terminations must be permanently labeled for identification and must be mechanically keyed to prevent improper connection. All connection points for external cables and wires must be easily accessible for connection / disconnection and must be permanently labeled. Prior to implementation, the Contractor must submit for approval the proposed labeling scheme and the samples of the proposed labels.

2.11 POWER SUBSYSTEM

A. Source:

1. The Communications Node PAC must derive 120 V (ac) power from the Communications Node UPS.

2. The TES TPSS will provide 24 VDC power fed through a DC-DC converted from a 125 VDC battery system as shown on the TPSS drawings, for the TPSS PAC and related equipment.

B. PAC Power Subsystem:

1. The power subsystem must convert power as necessary to operate the equipment and distribute this power to the subassemblies as required.

   a. Failure of the input source must not cause any damage to the power subsystem.

   b. The PAC must provide 24 VDC power for use in powering the input loops. Where PAC power supply is not sufficient to power input loops, the contractor must install two load-sharing 24 V DC power supplies, sized so that either power supply can handle the whole load. The Communications Node power supply must convert from 120 VAC to 24 VDC as required.

2. Power distribution must include switches or breakers such that all external power entering the PAC can be interrupted before it is distributed in the PAC. It must be possible to repair/replace any of the PAC modules in a completely powered down state by interrupting power at these switches or breakers.

C. Grounding: All equipment must be adequately grounded to safeguard all personnel from shock hazards. Equipment and system grounds must be designed to conform to Section 26 05 26, “Grounding and Bonding for Electrical systems."

2.12 PAC PROGRAMMING AND TEST SET

A. The Contractor must ensure the provided PAC equipment’s physical and software interface is compatible with the portable PAC Programming and Test Sets provided under the previous contracts. The test sets include an IBM compatible laptop computer with the software and hardware required to communicate with and program the existing Allen-Bradley PACs and the Contractor furnished PACs.

B. Configuration for PACs: The Contractor must ensure that the Contractor furnished PACs are compatible with the versions of the software installed at each test set.

C. Configuration for PAC Test Set Software: The Contractor must verify the Contractor furnished PACs for compatibility with the following functions of the test set software:

1. Simulation of the CCS messages to a PAC.
2. Simulation of PAC messages to the CCS.
3. Ability to capture and view the transmitted or received messages.
4. Ability to control the bit patterns of messages initiated from the Test Set. This must include the capability of forcing errors.
5. Selection of continuous and manual initiation of transmission.
6. Ability to access the PAC data base, examine/modify the data base parameters, and run calibration and diagnostic routines.

D. Communications: The Contractor furnished PACs must be compatible with communications ports and cables included with each test set.

E. User Interface: The Contractor furnished PACs must be compatible with the user interface included with each test set. The interface must be via the laptop video display. On-screen Help must be available for test conditions and setup variables.

2.13 MAINTAINABILITY

A. Maintenance Safety: PAC equipment must be designed, configured, and installed to optimize the safety of maintenance personnel.

B. Self-Tests: PACs must perform self-tests upon power on, upon command from the CCS and upon local command through Test Set or local control panel. Self-tests must include:

1. PAC main processor subsystem operation, including ROM checksum, RAM check, timer checks, and system bus check.
2. I/O subsystem and I/O card checks.
3. Data communications interface check.

C. Fault Detection and Reporting: Faults must be indicated to the Field Replaceable Unit level:

I/O card faults must be indicated on an LED on the card, and must be reported to the CCS. Upon introduction of replacement cards, the PAC must report to the CCS.

I/O subsystem faults must be indicated on an LED, and must be reported to the CCS.

The PAC must indicate locally the status of its ability to communicate with the Station LAN Switch.

1. The PAC must indicate the presence of operating power locally.

2. The PAC must report a restart condition to the CCS equipment after power on and after return to
3. operation following a power failure.

4. Equipment Replacement:

5.

PACs must provide a safe means for maintenance personnel to disable power to input/output circuits. The power-disabled state must be indicated locally.

D.

1. The PAC must provide for safe I/O card replacement. Upon replacement and power-up, card self-tests must automatically be initiated. Self-testing must include verification that the I/O configuration
2. of the replaced card matches the previous I/O configuration.

PAC MANAGEMENT UTILITY SOFTWARE

2.14

A. The Contractor must ensure the compatibility of the Contractor furnished PACs with the existing integrated display-based tool, which supports download data from the YMF to the field PACs. This tool allows the System Manager to download the following information to each PAC:

1. I/O point address data, i.e., correspondence of PAC memory register address to physical I/O card/point address.

2.

Control signal output hold time.

PART 3 -

3.01 **EXECUTION**

A.

FACTORY TESTS

3.02

A. PAC Data Communications: The Contractor must perform tests to verify the data communications message formats and protocol, including all I/O bit assignments, for all PACs using the location specific hardware and software.

1.

INSTALLATION - GENERAL

2. The Contractor must provide and install:

All PAC processing and I/O equipment and cabling, including all wiring and cabling between the Communications Node or TPSS where the PAC is housed and the I/O interface shown on the Contract Drawings.

Fiber optic and/or copper communication cables between PAC racks and the Station LAN Switch, as shown on Contract Drawings, as well as copper cables for all station, signals/communication room and other wayside I/O (up to the terminal block provided by others).

All SCADA equipment and devices must be installed in accordance with NFPA 70 and manufacturer's instructions.

Installation of SCADA equipment and associated raceways and cables must be in accordance with the Contractor’s approved Construction Drawings.

3. Provide all required interconnections, configurations, and adjustments for complete and operable SCADA functionality and network interface.

4. Rack mount equipment in cabinets or racks as indicated.

5. Mount equipment on enclosure backplanes using DIN rail as indicated.

6.

7.

Installation Test Procedures: Installation and test of PAC equipment must be conducted according to the approved Installation Plan and Field Test Procedures. PAC installation must not commence prior to VTA approval of the Installation Plan for the corresponding type of PAC installation.

B. Installation of PAC Equipment: Installation and testing of PAC equipment must include the following activities:

C.

1. Pre-installation/test inspection of available space and power, grounding system, cable runs and/or conduits, device terminal blocks, documentation on device terminal block wiring and testing performed by others.

2. Confirmation of the physical inventory data and pre-installation visual inspection of PAC equipment.

3. Post installation inspection of all equipment, mounting, cabling, and wiring.

3.03 FIELD DEVICE INTERFACE FOR DEVICES NOT PROVIDED UNDER THIS CONTRACT

A.

1. Contractor must provide, install, terminate and test cables for I/O between PAC equipment and field device interfaces as shown on the Contract Drawings.

a. Contractor must pull cables from pull boxes nearest to each field device interface location. The contractor must terminate the I/O cable to interface terminal boards at each field device interface.

b.

c. For wayside devices such as traffic detector loops, UPS and sump high water alarms, the field device interface is located at the corresponding device controller or control panel location (e.g., the interface location for traffic detector loops is at the corresponding traffic signal controller).

2. For TES devices, the field device interface is located at the PAC, at the corresponding substation.

3. For station facilities, the field device interface is located at the corresponding station case or room (e.g., station elevator I/O interface is at the corresponding elevator machine room).

4. Contractor must coordinate with VTA and the corresponding installation contractor to determine and agree on electrical characteristics of I/O signals.

3.04 Contractor must coordinate with the corresponding installation contractor to determine assignment of terminal board positions to I/O points.

Contractor must provide and install cross-connect wiring, bridge connect or equivalent to physically complete the I/O circuit at the terminal board.

FIELD TESTING

A. Testing of Installed PACs: Records must be maintained for all PAC installation and test activities, and must be delivered to the VTA. Tests must include as a minimum:

1. Equipment diagnostics.

2. Data communications testing for communications between the PAC and the CCS.

3. Signal testing for indication input at the PAC terminal block.

4. Signal testing for control outputs at the PAC terminal block.

5. Device and alarm testing using the Test Set and verification of the associated Device Interface Management Database.

B. Conduct field testing in three phases:

1. Installation Verification: Verify correct termination of all field wiring and inter-facility cabling using Contractor-prepared interconnection diagrams.

   a. Test sheets must record test status for all monitoring and control points, each row for each point on each test sheet must be witnessed by VTA and signed by VTA, before test results, as part of the overall test plan and test procedures will be accepted from the Contractor by VTA.

   b. Handwritten results on test sheets are the only acceptable form of recording test results, point by point.

2. Functional Testing: Functional Testing must include:

   a. SCADA I/O points testing from interface terminals to OCC, jumpering of SCADA points is acceptable at interface terminals, and checking interposing relays status for outputs is acceptable at the interface terminals. The final approved I/O list provided by the Contractor must be used as the basis for functional testing at each location.

3. End-to-End/Performance Testing:

   a. Commands and indications must be tested from the VTA OCC to verify the integrity of the communication links in the final configuration and to verify proper integration between the different systems. Each interface terminal and associated point must be tested to confirm the point is correctly displayed at the local PLC panel, and at the OCC, and that the control function output from interposing relays is correct to the field device.

   b. Each field device for each SCADA point must be actuated by Contractor personnel to verify that the device status is correctly displayed on the appropriate local panels and at the OCC, and for control functions from OCC to the field device, confirming correct control of the device, through the interposing relays and to the device itself.

   c. At this final stage of the project, field devices may not be simulated by shorting the device signal wires for status monitoring, or voltmeter for control output, unless specifically authorized, point by point, in writing by VTA.

3.05 TRAINING

A. Maintenance Training must include the following:

1. Instruction and "hands-on" demonstration of the operation of all system components and the entire system including program changes and functions

Operation of internal processor diagnostic and self-test routines

Equipment settings and test procedures

Equipment replacement

Alarm recognition, including awareness of alarm significance and criticality of subsequent action(s)

2.

3. Equipment and System troubleshooting

4.

5. **WORK TO BE PERFORMED BY VTA**

6. VTA will configure the SCADA equipment and software at the VTA OCC to monitor and control the SCADA system based on information provided by the Contractor.

3.06

A. The VTA will make personnel available at the VTA OCC as required to support End to End testing by the Contractor.

B.

FIELD QUALITY CONTROL

PART 4 -

A. Quality: The quality of the Communications System installation must be ensured through the performance of tests and inspections made during the progress of this Contract and after completing the installation of equipment. Perform field installation inspections to ensure that all equipment furnished under this Contract is installed in compliance with the technical specifications and workmanship standards and practices.

END OF SECTION

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SECTION 28 46 00

FIRE ALARM SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. This section of the specification includes the furnishing, installation, connection and testing of the microprocessor controlled, intelligent reporting fire alarm equipment required to form a complete, operative, coordinated system. It shall include, but not be limited to, alarm initiating devices, Fire Alarm Control Panel (FACP) ”Elevator Recall Control and Supervisory Panel”, auxiliary control devices, and wiring as shown on the drawings and specified herein.

B. The fire alarm system shall comply with requirements of NFPA Standard No. 72 for Local Protected Premises Signaling Systems except as modified and supplemented by this specification. The system field wiring shall be supervised either electrically or by software-directed polling of field devices.

1. The Secondary Power Source of the fire alarm control panel will be capable of providing at least 24 hours of backup power with the ability to sustain 5 minutes in alarm at the end of the backup period.

C. The fire alarm system shall be manufactured by an ISO 9001 certified company and meet the requirements of BS EN9001: ANSI/ASQC Q9001-1994.

D. The FACP and peripheral devices shall be manufactured 100% by a single U.S. manufacturer (or division thereof).

E. Underwriters Laboratories Inc. (UL) - USA:

1. The FACP shall be ANSI 864, 9th Edition Listed. Systems listed to ANSI 864, 8th edition (or previous revisions) shall not be accepted.

F. The installing company shall employ NICET (minimum Level II Fire Alarm Technology) technicians on site to guide the final check-out and to ensure the systems integrity.

1.02 SCOPE

A. An intelligent, microprocessor-controlled, fire alarm detection system shall be installed in accordance to the project specifications and drawings.

B. Basic Performance:

1. Initiation Device Circuits (IDC) shall be wired NFPA Style B (Class B) as part of an addressable device connected by the SLC Circuit.

2. All circuits shall be power-limited, per UL864 requirements.

3. A single ground fault or open circuit on the system Signaling Line Circuit shall not cause system malfunction, loss of operating power or the ability to report an alarm.

4. Alarm signals arriving at the main FACP shall not be lost following a primary power failure or outage of any kind until the alarm signal is processed and recorded.

5. Panel shall meet requirements of UL-864 Ninth Edition

C. Basic System Functional Operation: When a fire alarm condition is detected and reported by one of the system initiating devices, the following functions shall immediately occur:

1. The Zone Alarm LED for the particular zone in alarm shall light.

2. In response to a fire alarm condition, the system will activate all modules to recall the elevator and send fire alarm to the VTA Operation Control Center.

1.03 SUBMITTALS

A. Refer to Section 26 05 00, 1.06, Submittals.

B. For equipment other than that specified, the contractor shall supply proof that such substitute equipment equals or exceeds the features, functions, performance, and quality of the specified equipment.

C. Shop Drawings:

1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.

2. Include manufacturer's name(s), model numbers, ratings, power requirements, equipment layout, device arrangement, complete wiring point-to-point diagrams, and conduit layouts.

3. Show system layout, configurations, and terminations.

D. Manuals:

1. Submit simultaneously with the shop drawings, complete operating and maintenance manuals listing the manufacturer's name(s), including technical data sheets.

2. Wiring diagrams shall indicate internal wiring for each device and the interconnections between the items of equipment.

3. Provide a clear and concise description of operation that gives, in detail, the information required to properly operate the equipment and system.

E. Closeout Submittals: Submit in accordance with Sec. 26 05 00.

1. Red-lined construction drawings.

2. Operations and Maintenance manuals.

3. Wiring diagrams.

4. Manufacturer’s warranties.

5. Final test and commissioning report.

1.04 APPLICABLE STANDARDS AND SPECIFICATIONS

The specifications and standards listed below form a part of this specification. The system shall fully comply with the latest issue of these standards, if applicable.

A. National Fire Protection Association (NFPA) - USA:

1. No. 70 National Electric Code (NEC)

2. No. 72 National Fire Alarm Code

3. No. 101 Life Safety Code

B. The system and its components shall be Underwriters Laboratories, Inc. listed under the appropriate UL testing standard as listed herein for fire alarm applications and the installation shall be in compliance with the UL listing.

C. Local and State Building Codes.

D. All requirements of the Authority Having Jurisdiction (AHJ).

1.05 MEASUREMENT AND PAYMENT

A. Full compensation for providing the Fire Alarm System shall be considered as included in the bid item for Story Station Electrical Work and no additional compensation will be allowed therefore.

PART 2 - PRODUCTS

2.01 EQUIPMENT AND MATERIAL, GENERAL

A. All equipment and components shall be new, and the manufacturer's current model. The materials, appliances, equipment and devices shall be tested and listed by a nationally recognized approvals agency for use as part of a fire protective signaling system, meeting the National Fire Alarm Code.

B. All equipment and components shall be installed in strict compliance with manufacturers' recommendations. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc., before beginning system installation.

C. All equipment shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place (e.g., detectors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.

D. All equipment must be available "over the counter" through the Security Equipment Distributor (SED) market and can be installed by dealerships independent of the manufacturer.

2.02 CONDUIT AND WIRE

A. Conduit:

1. Conduit shall be in accordance with The National Electrical Code (NEC), local and state requirements.

2. Where required, all wiring shall be installed in conduit or raceway. Conduit fill shall not exceed 40 percent of interior cross sectional area where three or more cables are contained within a single conduit.

3. Cable must be separated from any open conductors of power, or Class 1 circuits, and shall not be placed in any conduit, junction box or raceway containing these conductors, per NEC Article 760-29.

4. With the exception of telephone connections, wiring for 24 volt DC control, alarm notification, emergency communication and similar power-limited auxiliary functions may be run in the same conduit as initiating and signaling line circuits. All circuits shall be provided with transient suppression devices and the system shall be designed to permit simultaneous operation of all circuits without interference or loss of signals.

5. Conduit shall not enter the fire alarm control panel, or any other remotely mounted control panel equipment or backboxes, except where conduit entry is specified by the FACP manufacturer.

6. Conduit shall be 3/4 inch (19.1 mm) minimum.

B. Wire:

1. All fire alarm system wiring shall be new.

2. Wiring shall be in accordance with local, state and national codes (e.g., NEC Article 760) and as recommended by the manufacturer of the fire alarm system. Number and size of conductors shall be as recommended by the fire alarm system manufacturer, but not less than 18 AWG (1.02 mm) for Initiating Device Circuits and Signaling Line Circuits.

3. All wire and cable shall be listed and/or approved by a recognized testing agency for use with a protective signaling system.

4. Wire and cable not installed in conduit shall have a fire resistance rating suitable for the installation as indicated in NEC 760 (e.g., FPLR).

5. Wiring used for the multiplex communication circuit (SLC) shall be twisted non-shielded and support a minimum wiring distance of 10,000 feet when sized at 12 AWG.

6. All field wiring shall be electrically supervised for open circuit and ground fault.

7. The fire alarm control panel shall be capable of T-tapping NFPA Style 4 (Class B) Signaling Line Circuits (SLCs). Systems which do not allow or have restrictions for the number of T-taps, length of T-taps etc., are not acceptable.

C. Terminal Boxes, Junction Boxes and Cabinets:

1. All boxes and cabinets shall be UL listed for their use and purpose.

D. The fire alarm control panel shall be connected to a separate dedicated branch circuit, maximum 20 amperes. This circuit shall be labeled at the main power distribution panel as FIRE ALARM. Fire alarm control panel primary power wiring shall be 12 AWG. The control panel cabinet shall be grounded securely to either a cold water pipe or grounding rod.

2.03 MAIN FIRE ALARM CONTROL PANEL

A. The FACP shall be a Gamewell Model GWF7075 or approved equal and shall contain a microprocessor based Central Processing Unit (CPU). The CPU shall communicate with and control the following types of equipment used to make up the system: intelligent addressable smoke detectors, addressable modules.

B. Operator Control

1. Acknowledge Switch:

   a. Activation of the control panel Acknowledge switch in response to new alarms, supervisory and/or troubles shall silence the local panel piezo electric signal and change the alarm, supervisory and trouble LEDs to steady-ON mode.

2. Alarm Silence Switch:

   a. Activation of the alarm silence switch shall cause all programmed alarm relays to return to the normal condition after an alarm condition. The selection of relays that are silenceable by this switch shall be fully field programmable within the confines of all applicable standards. The FACP software shall include silence inhibit and auto-silence timers. System Reset Switch:

   b. Activation of the System Reset switch shall cause all electronically-latched initiating devices, appliances or software zones, as well as all associated output devices and circuits, to return to their normal condition.

3. Lamp Test:

   The System RESET switch shall also function as a Lamp Test switch and shall activate all system LEDs and light each segment of the display.

C. System Capacity and General Operation

1. The control panel shall provide, or be capable of, expansion to 25 intelligent/addressable devices of any type, detector or module.

2. The control panel shall include two Form-C programmable relays, which can be used for Alarm, and Supervisory and a fixed Trouble relay rated at a minimum of 2.5 amps @ 24 VDC. It shall also include 2 programmable Notification Appliance Circuits (NACs) capable of being wired as NFPA Style Y (Class B). Either programmable Notification circuit shall also be capable of providing auxiliary power when programmed as such.

3. The control panel must have a built in annunciator.

4. The system shall allow the programming of any input to activate any output.

5. The FACP shall provide the following features:

   a. Drift compensation to extend detector accuracy over life. Drift compensation shall also include a smoothing feature, allowing transient noise signals to be filtered out.

b. Detector sensitivity test, meeting requirements of NFPA 72, Maintenance alert, with two levels (maintenance alert/maintenance urgent), to warn of excessive smoke detector dirt or dust accumulation.

c. Alarm verification, with counters and a trouble indication to alert maintenance personnel when a detector enters verification an excessive number of times.

d. Periodic detector test, conducted automatically by the software.

e. Walk test mode shall be a standard feature of the fire alarm control panel. The walk test feature shall function so that each alarm input tested will operate the associated notification appliance for three seconds. The FACP will then automatically perform a reset and confirm normal device operation.

D. Signaling Line Circuit (SLC)

1. The SLC interface shall provide power to and communicate with up to 25 devices of any type including: intelligent detectors (photoelectric) intelligent modules. Each SLC shall be capable of NFPA 72 Style 4 (Class B) wiring.

E. Enclosures:

1. The control panel shall be housed in a UL-listed cabinet suitable for surface mounting. The cabinet and front shall be corrosion protected and painted red via the powder coat method with manufacturer's standard finish.

2. The back box and door shall be constructed of steel with provisions for electrical conduit connections into the sides and top.

3. The door shall provide a key lock and shall provide for the viewing of all indicators.

F. Power Supply:

1. The main power supply for the fire alarm control panel shall provide up to 2.0 amps of available power for the control panel and peripheral devices.

2. The power supply shall provide an integral battery charger

3. The main power supply shall continuously monitor all field wires for earth ground conditions.

4. The main power supply shall operate on 120 VAC, 60 Hz, and shall provide all necessary power for the FACP.

G. Specific System Operations

1. Alarm Verification: Each of the intelligent addressable smoke detectors in the system may be independently programmed for verification of alarm signals. The alarm verification time period shall not exceed 250 seconds.

2. Zone Disable: Any addressable device in the system may be enabled or disabled through the system keypad.

3. Zone Read: The system shall be able to display the following point status:

a. Alarm ID

b. Supervisory ID

c. Trouble ID

4. Automatic Detector Maintenance Alert: The fire alarm control panel shall automatically interrogate each intelligent detector and shall analyze the detector responses over a period of time. If any intelligent detector in the system responds with a reading that is above or below normal limits, then the system will enter the trouble mode, and the particular detector will be annunciated on the system display. This feature shall in no way inhibit the receipt of alarm conditions in the system, nor shall it require any special hardware, special tools or computer expertise to perform.

5. The fire alarm control panel shall include Walk Test functions - Silent and Audible. It shall include the ability to test initiating device circuits and Notification Appliance Circuits from the field without returning to the panel to reset the system. The operation shall be as follows:

   a. Alarming an initiating device shall activate programmed outputs, which are selected participate in Walk Test.

6. Supervisory Operation: An alarm from a supervisory device shall cause the appropriate indication on the control panel display, light a Zone supervisory LED.

7. Signal Silence Operation: The FACP shall have the ability to program each output circuit to deactivate upon depression of the Signal Silence switch.

2.04 SYSTEM COMPONENTS

A. Intelligent Photoelectric Smoke Detector

1. The detectors shall use the photoelectric (light-scattering) principal to measure smoke density and shall, on command from the control panel, send data to the panel representing the analog level of smoke density.

2. Detector shall be provided on a twist-lock base.

3. It shall be possible to perform a calibrated sensitivity and performance test on the detector without the need for the generation of smoke. The test method shall test all detector circuits.

4. A visual indication of an alarm shall be provided by a latching Light Emitting Diode (LED), on the detector, which may be seen from ground level over 360 degrees. The LED shall periodically flash to indicate that the detector is in communication with the control panel.

5. All field wire connections shall be made to the base through the use of a clamping plate and screw.

B. Addressable Control Relay Module

1. Addressable control relay modules shall be provided to control the operation of elevator recall and send fire alarm to VTA Operation Control Center.

2. The control module shall mount in a standard 4-inch square, 2-1/8 inch deep electrical box, or to a surface mounted backbox.

3. The control relay module will provide a dry contact, Form-C relay. The relay coil shall be magnetically latched to reduce wiring connection requirements, and to insure that 100% of all auxiliary relays may be energized at the same time on the same pair of wires.

4. The control relay module shall be suitable for pilot duty applications and rated for a minimum of 0.6 amps at 30 VDC.

C. Field Wiring Terminal Blocks

For ease of connection for heavy solid gauge wire, all panel I/O wiring terminal blocks be screw type barrier strips and have sufficient capacity for #22 to #12 AWG wire.

D. Hor n / Strobes shall be ADA / NFPA / ANSI compliant and meet OSHA 29 Part 1910.165 with 2 selectable tones and dB levels, weatherproof and be as manufactured by System Sensor, Wheelock or approved equal.

2.05 BATTERIES

A. Upon loss of Primary (AC) power to the control panel, the batteries shall have sufficient power to power the fire alarm system for 24 hours, followed by 5 minutes of alarm.

B. The batteries are to be completely maintenance free. No liquids are required. Fluid level checks for refilling, spills, and leakage shall not be required.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Installation shall be in accordance with the NEC, NFPA 72, local and state codes, as shown on the drawings, and as recommended by the major equipment manufacturer.

B. All conduit, junction boxes, conduit supports and hangers shall be concealed in finished areas and may be exposed in unfinished areas. Smoke detectors shall not be installed prior to the system programming and test period. If construction is ongoing during this period, measures shall be taken to protect smoke detectors from contamination and physical damage.

3.02 TEST

The service of a competent, NICET level II technician shall be provided to technically supervise and participate during all of the adjustments and tests for the system. All testing shall be in accordance with NFPA 72.

A. Before energizing the cables and wires, check for correct connections and test for short circuits, ground faults, continuity, and insulation.

B. Open initiating device circuits and verify that the trouble signal actuates.

C. Open and short signaling line circuits and verify that the trouble signal actuates.

D. Ground all circuits and verify response of trouble signals.

E. Check installation, supervision, and operation of all intelligent smoke detectors using the walk test.

F. Each of the alarm conditions that the system is required to detect should be introduced on the system. Verify the proper receipt and the proper processing of the signal at the FACP the correct activation of the control points.

G. When the system is equipped with optional features, the manufacturer's manual shall be consulted to determine the proper testing procedures. This is intended to address such items as verifying controls performed by individually addressed or grouped devices, sensitivity monitoring, verification functionality and similar.

3.03 FINAL INSPECTION

A. At the final inspection, a NICET minimum Level II fire alarm technology technician shall demonstrate that the system functions properly in every respect.

3.04 INSTRUCTION

A. Instruction shall be provided as required for operating the system. Hands-on demonstrations of the operation of all system components and the entire system including program changes and functions shall be provided.

B. The contractor or installing dealer shall provide a user manual indicating "Sequence of Operation."

END OF SECTION 28 46 00

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