

READ THIS FIRST

Notice to the Design Engineer, this document is part of Facilities and Infrastructure standards for Electrical Systems. Designers are advised to NOT use this template (*.doc) document as part of any project contract documents. Designers shall use the Port of Seattle MasterSpec specifications from the following link:

<https://www.portseattle.org/page/guide-specifications>.

Designers shall edit the corresponding Port's MasterSpec specification to meet the F&I Electrical Standard outlined in this specification. Note that Port's MasterSpec specifications contain specifications and languages for both Aviation and Maritime Divisions. F&I Standards are strictly for Aviation Division, and any Maritime related specs or languages should be removed from the project specifications.

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 AND NOTES TO DESIGNER

- A. Section Includes:
 - 1. Direct-buried conduit, ducts, and duct accessories.
 - 2. Concrete-encased conduit, ducts, and duct accessories.
 - 3. Handholes and boxes.
 - 4. Manholes.
- B. All underground conduits shall be 2" diameter minimum.
 - 1. Except for conduit(s) terminating to devices or equipment.
- C. For medium voltage primary distribution ductbank, provide 6" conduits.
- D. All new multi-conduit duct banks shall include duct bank profiles in the design.
 - 1. A minimum of four spare conduit shall be included in multi-conduit duct bank system.
- E. Reinforce Concrete Encased Ductbank Conduit Requirements:
 - 1. Under roadways: PVC Schedule 80.
 - 2. Runway areas: Galvanized rigid steel or PVC Schedule 80.
 - 3. Other locations: NEMA TC 2 Schedule 40 PVC with NEMA TC 3 PVC conduit and tubing fittings.

4. Non-metallic ducts shall be used for short runs to remotely located small loads
- F. Direct Burial Conduit – for low voltage applications only:
1. Under Roadways: PVC Schedule 80
 2. Runway areas: Galvanized rigid steel or PVC Schedule 80.
 3. Other locations: NEMA TC2 Schedule 40 PVC with NEMA TC3 PVC conduit and tubing fittings.
- G. Manhole and handhole foldouts shall be provided in the design for the locations and types listed below.
1. AOA areas (airfield, apron, access road, etc). This includes lighting, power (low voltage and medium voltage), communications
 2. All type of medium voltage systems
 3. Communication
- H. All manholes and handholes shall be strategically located to minimize bend radius between underground utility structures to no more than 270 deg.
1. Where the duct banks between two manholes and/or handholes are straight, the manholes/handholes shall be located no more than 500 feet apart.
 2. Where the duct banks between two manholes and/or handholes are not straight, the manholes/handholes shall be located no more than 300 feet apart.
- I. New manhole and handhole shall be provided with a two-inch pipe that drain to the nearest underground drainage system/outlet.
- J. Designers shall provide with a two-inch drain pipe (if it does not exist) in existing underground (electrical or communication) structures where new penetration is made into the existing structure.

1.3 DEFINITIONS

- A. Airfield: The area prepared for accommodation, landing and take-off of aircraft.
- B. AOA: Airport Operation Area
- C. Ramp: Any outdoor area, including aprons and hardstands, on which aircraft are normally fueled, defueled, stored, parked, maintained or serviced.
- D. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 1. Include duct-bank materials, including separators and miscellaneous components.

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2. Include ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Include accessories for manholes, handholes, boxes, and other utility structures.
4. Include warning tape.
5. Include warning planks.

B. Shop Drawings:

1. Precast or Factory-Fabricated Underground Utility Structures:
 - a. Include plans, elevations, sections, details, attachments to other work, and accessories.
 - b. Include duct entry provisions, including locations and duct sizes.
 - c. Include reinforcement details.
 - d. Include frame and cover design and manhole frame support rings.
 - e. Include Ladder details.
 - f. Include grounding details.
 - g. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
 - h. Include joint details.
2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:
 - a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
 - b. Include duct entry provisions, including locations and duct sizes.
 - c. Include cover design.
 - d. Include grounding details.
 - e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.5 INFORMATIONAL SUBMITTALS

- A. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
 1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
 2. Drawings shall be signed and sealed by a qualified professional engineer.
- B. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.
- C. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.
- D. Source quality-control reports.
 1. Certification of proof load testing for castings is required with all construction submittals for Port approval prior to acceptance.

- E. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

1.7 FIELD CONDITIONS

- A. Ground Water: shall be per the applicable engineer of record.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR DUCTS AND RACEWAYS

- A. Comply with NFPA 70 "National Electrical Code" and ANSI C2 "National Electrical Safety Code".

2.2 CONDUIT

- A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.
- B. Steel Fittings: Zinc-coated cast malleable ferrous metal threaded fittings with neoprene cover gasket on each fitting installed outdoors.
- C. Seal Bushings: Provide O.Z. compound bushing on each conduit passing from one space into another, which is normally at lower temperature.
- D. Hubs: Provide Appleton "Hub" Series, or Thomas and Betts "370" series hub or F&I approved equal on each conduit terminating in a box where a hub was not previously provided.
- E. Unions: Provide Appleton Type EC or Thomas and Betts Erickson Coupling conduit unions or F&I approved equal.
- F. RNC: NEMA TC 2, Type EPC-40-PVC or Type EPC-80-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.
 - 1. Provide PVC fittings or PVC conduit and suitable watertight connections where PVC conduit connects to galvanized steel conduit.

2.3 PRECAST CONCRETE HANDHOLES AND BOXES

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

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1. Utility Vault/Oldcastle Precast Group.
2. Utility Concrete Products, LLC.
3. Concast

B. Comply with ASTM C 858 for design and manufacturing processes.

C. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom. Walls and bottom shall be constructed to support rating of cover. Frame and cover shall form top of enclosure and shall support highway rated covers as defined below.

1. Frame and Cover: Reinforced concrete or weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
 - a. For covers located in the Air Operation Area (AOA), provide aircraft-rated covers in compliance with Specification Section 334241.
 - b. For covers located a **minimum of 10 feet off of a vehicle services road** in landscape/vegetation areas or areas where vehicle traffic does not have the capability to exceed 5 mph, provide HS20 highway rated covers.
 - c. For all other covers located outside of the AOA areas, provide manhole covers that meet non-AOA areas requirements per Specification Section 334241.
 - d. Cover to include insert of other devices to facilitate lifting.
 - e. Cover to contain locking devices similar to REA or FARGO.
 - f. Cover Hinges: Concealed, with hold-open ratchet assembly.
 - g. Cover Handle: Recessed.
2. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
3. Cover Legend: Molded lettering, as indicated for each service.
4. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.
5. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
 - a. Type and size shall match fittings to duct or conduit to be terminated.
 - b. Fittings shall align with elevations of approaching ducts and be located near interior corners of handholes to facilitate racking of cable.

2.4 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. General Requirements for Handholes and Boxes: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

1. Color: Gray.
2. Configuration: Units shall be designed for flush burial and have closed bottom unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, as indicated for each service.

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6. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 7. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.
- B. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers made of reinforced concrete or cast iron.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carson Industries LLC.
 - b. Christy Concrete Products.
 - c. Oldcastle Precast
 - d. Quazite: Hubbell Power System, Inc.

2.5 PRECAST MANHOLES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Oldcastle Precast Group/Utility Vault.
 2. Utility Concrete Products, LLC.
 3. Jensen Precast
- B. Comply with ASTM C 858.
- C. Inspect structures to ASTM C 1037.
- D. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.
- E. Precast Manholes: Interlocking mating sections complete with accessories, hardware, and features indicated.
1. Capable of supporting loads that are expected at the installed location. Walls and floor shall be reinforced to support rated strength of covers.
- F. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
1. Type and size shall match fittings to duct or conduit to be terminated.
 2. Fittings shall align with elevations of approaching ducts and be located near interior corners of manholes to facilitate racking of cable.
- G. Concrete Knockout Panels: 1-1/2 to 2 inches thick, for future conduit entrance and for ground rod.

- H. Joint Sealant: Continuous extrusion of asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.6 CAST-IN-PLACE MANHOLES

- A. Description: Underground utility structures, constructed in place, complete with accessories, hardware, and features. Include concrete knockout panels for conduit entrance and sleeve for ground rod.
1. Reinforced to strength required at project location. Manhole walls and floors to be reinforced to support rated strength of cover.
 2. If possible, install manholes and vaults that are one size larger than required by NFPA 70.
 3. Manhole Floor: Provide minimum two holes for drainage, two inches minimum diameter and minimum 2 feet of gravel beneath manhole, except where drawing shows an internal sump and sump pump.
Provide 4" drain line from manhole to sump or storm sewer, as required.
- B. Structural Design Loading: As specified in "Underground Enclosure Application" Article.

2.7 UTILITY STRUCTURE ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Underground Devices
 2. Oldcastle Precast/Utility Vault
 3. Utility Concrete Products
 4. Jensen Precast.
- B. Manhole Frames, Covers, and Ring Components: Comply with structural design loading specified for manhole.
1. Frame and Cover: Weatherproof, reinforced concrete or cast-iron and capable of supporting loads that are expected for the installed location.
 - a. For covers located in the Air Operation Area (AOA), provide aircraft-rated covers in compliance with Specification Section 334241.
 - b. For covers located in landscape/vegetation areas or areas where vehicle traffic does not have the capability to exceed 5 mph, provide HS20 highway rated covers.
 - c. For all other covers located outside of the AOA areas, provide manhole covers that meet non-AOA areas requirements per Specification Section 334241.
 - d. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - e. Special Covers: Recess in face of cover designed to accept finish material in paved areas.

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- f. Provide lifting points on manhole covers.
2. Cover Legend: Manhole ID machine welded into cover, cast iron with cast-in legend.
 - a. Cast-in Legend: For electrical power manholes, identification shall be "Electrical #" where # is the manhole number, provided by the Port.
 - b. Cast-in Legend: For telecom manholes, identification shall be "Comm #" where # is the manhole number, provided by the Port.
 - c. For steel cover: Molded lettering
 3. Manhole Ring Components: Precast concrete rings with dimensions and strength matched to those of highway rated roof opening.
 - a. Mortar for Ring and Frame and Cover Joints: Strength to match highway rated cover.
 - b. Where required, seal joints watertight using preformed plastic or rubber conforming to ASTM C 990. Install sealing material according to the sealant manufacturers' printed instructions.
- C. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.
- D. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch-diameter eye, and 1-by-4-inch bolt.
1. Working Load Embedded in 6-inch, 4000-psi Concrete: 13,000-lbf minimum tension.
- E. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch-diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
1. Ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.
- F. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded precast channel inserts of hot-dipped galvanized or stainless steel; 1/2-inch ID by 2-3/4 inches deep minimum, flared to 1-1/4 inches minimum at base. 3'-0" on center.
1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.
- G. Ground Rod Knock Out: 3-inch knock out for installation of ground rod. Install ground rods in accordance with 260526 – Ground and Bonding for Electrical Systems.
- H. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch (13-mm) bolt, 5300-lbf (24-kN) rated pullout strength, and minimum 6800-lbf (30-kN) rated shear strength. Cast-in-place inserts are not allowed unless cast by vault manufacturer.
- I. Cable Rack Assembly: Heavy duty, nonmetallic, 50% glass reinforced nylon or other nonmetallic material having equal mechanical strength, thermal resistance, chemical resistance, dielectric strength and physical properties.

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1. Stanchions: Nominal 36 inches high by 4 inches wide, with multiple arm mounting holes and recessed bolt mounting holes.
 2. Arms: Arranged for secure, drop in attachment in horizontal position at any location on cable stations, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches with 450 lb. minimum capacity to 20 inches with 250 lb. minimum capacity. Top of arm shall be nominally 4 inches wide and shall have slots along full length for cable ties.
- J. Duct-Sealing Compound: 3M Fireseal, Hilti or Tremco.
- K. Manhole Ladders: Where ladders are called for in design, UL-listed nonconductive, structural grade fiberglass-reinforced resin, specifically designed for electrical manhole use. Arrangement per engineer of record.

2.8 DUCTBANK CONCRETE

- A. Material: Provide as follows:
1. Gravel: 3/8 inch maximum
 2. Slump: 4 inches maximum
 3. Compressive strength: 3000psi at 28 days
 4. Color: Dye ductbank concrete red.
- B. Reinforcing (except when GRC is used): Provide steel conforming to ASTM A15. Provide #4 rebar top and bottom, 2'-0" lap at splices (typically 4 places) and #4 rebar at 18 inches on center around perimeter with 3" minimum cover.

2.9 BACKFILL MATERIAL

- A. Designer shall coordinate trenching and backfill with Civil trenching and backfill sections.
- B. Lower Trench Portion (surrounding ductbank): Sandy silt, clay silt, sand clay or other material free of stones and conglomerates larger than 2 inches diameter.
- C. Upper Trench Portion (from one foot above ductbank, up to grade): On-site backfill material consisting of rock, soil or soil-rock mixture containing no rocks or lumps over 6" diameter.
- D. Controlled Density Fill (CDF)
1. CDF shall be a mixture of Portland cement, fly ash, aggregates, water and admixtures proportioned to provide a non-segregating, self-consolidating and free flowing material which will result in a hardened, dense, non-settling and excavatable fill.
 2. CDF shall be used as a fill above utilities wherever non-settling backfill is required.
 3. CDF shall be batched and mixed in accordance with Section 6-02.3 of the WSDOT/APWA Specifications.

4. CDF to be batched to provide a flowing, non-segregating mix with a slump between 6 inches and 8 inches.

2.10 SOURCE QUALITY CONTROL

- A. Test and inspect precast concrete utility structures according to ASTM C 1037.
- B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 1. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 2. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - INSTALLATION

3.1 GENERAL

- A. Where working in existing manhole with energized cables, all installation shall be per the NEC and shall be performed by electricians or under the supervision of a electrician licensed in the State of Washington.
- B. Existing manholes and handholes within the construction zones shall be provided with a $\frac{3}{4}$ " steel plate cover to maintain protections of the manhole lids and covers. This includes, but is not limited, to construction areas, staging areas, and haul routes.

3.2 DELIVERY, STORAGE AND HANDLING

1. Deliver ducts to site with ends capped. Store non-metallic ducts with supports to prevent bending, warping and deforming.
2. Store precast concrete vaults at site to prevent physical damage.
3. Lift and support precast vaults only at designated lifting or supporting points.

3.3 PREPARATION

- A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Port Construction Manager if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.
- B. Locate all existing utilities in the area prior to performing any excavation.

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- C. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.
- D. Clear and grub vegetation to be removed, and protect vegetation to remain according to Section 311000 "Site Clearing." Remove and stockpile topsoil for reapplication according to Section 311000 "Site Clearing."

3.4 UNDERGROUND DUCT APPLICATION

- A. General:
 - 1. Underground Ducts for Electrical Feeders, Telephone and Communication Circuits: RNC Type EPC 40-PVC encased in reinforced concrete, except as noted below.
 - 2. All underground conduit to be a minimum of 2 inch standard trade size.
 - 3. All underground non-metallic conduit shall be labeled for underground use and 90°C conductors.
- B. Ducts for Electrical Cables rated greater than 600V:
 - 1. RMC, galvanized rigid steel, ANSI C80.1 for use above ground and underground.
 - 2. RNC, NEMA TC2 Type EPC-40-PVC, 2" diameter trade size minimum, with NEMA TC3 PVC fittings in concrete-encased duct bank except under roadways and runway areas.
 - 3. RNC, NEMA TC2, Type EPC-80 PVC, 2" diameter trade size minimum with NEMA TC3 PVC fittings in concrete encased ductbank under runway areas.
 - 4. RMC, concrete incased under roadways and in runway areas.
- C. Ducts for Electrical Cables 600 V and Less:
 - 1. RMC, galvanized rigid steel, ANSI C80.1.
 - 2. RNC, NEMA TC2 Type EPC-40-PVC, in direct-buried duct bank except under roadways or in runway areas.
 - 3. RNC, NEMA TC2 Type EPC-80-PVC, direct buried in runway areas.
 - 4. RMC, direct burial under roadways and in runway areas.
- D. Under-slab conduit installations:
 - 1. For conduits 2" and larger installed under floor slabs:
 - a. Conduits shall be concrete encased and reinforced with steel reinforcing rods.
 - b. Group conduits in an orderly manner.
 - c. Install conduits so that top of conduit is 24" below top of slab.
 - 2. For conduits less than 2" diameter, bed in sand or soil that is free from rocks or debris with sharp edges.

3.5 UNDERGROUND ENCLOSURE APPLICATION

- A. Handholes and Boxes for 600 V and Less:
1. Units, located in the Air Operation Area (AOA), shall be aircraft-rated in compliance with Specification Section 334241.
 2. Units, located in landscape/vegetation areas or areas where vehicle traffic does not have the capability to exceed 5 mph, shall be HS20 highway rated.
 3. For all other Units located outside of the AOA areas, provide handhole rated for non-AOA areas per Specification Section 334241.
- B. Manholes: Precast or cast-in-place concrete.
1. Units, located in the Air Operation Area (AOA), shall be aircraft-rated in compliance with Specification Section 334241.
 2. Units, located in landscape/vegetation areas or areas where vehicle traffic does not have the capability to exceed 5 mph, shall be HS20 highway rated.
 3. For all other Units located outside of the AOA areas, provide handhole rated for non-AOA areas per Specification Section 334241.
 4. Designer shall evaluate other applications during design.

3.6 EARTHWORK

- A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Depth: 24 inch minimum cover over top of conduit ductbank.
1. For ductbanks in the airfield, minimum cover shall be 30 inches.
- C. Width: Excavate to minimum width consistent with stability of sides.
- D. Muck Excavation: Where much or unstable material is encountered, over-excavate and backfill to attain proper grade with coarse sand, gravel or CDF.
- E. Rock Excavation: Where rock pad is used for conduit trench, over-excavate 6 inches below the ductbanks and refill and compact with selected backfill material of same composition.
- F. Bedding: Bottom of excavation to be firm, stable and at uniform density.
- G. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- H. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with engineer of record requirements.

3.7 DUCT INSTALLATION

- A. Install ducts according to NEMA TCB 2.
- B. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes, to drain in both directions.
- C. Curves and Bends: Use manufactured galvanized rigid steel elbows for stub-ups at equipment and at building entrances with minimum radius of 36 inches.
- D. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.
- E. Installation Adjacent to High-Temperature Steam Lines: Where duct banks are installed parallel to underground steam lines, perform calculations showing the duct bank will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct bank crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.
- F. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch ducts, and vary proportionately for other duct sizes.
 - 1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell without reducing duct line slope and without forming a trap in the line.
 - 2. Grout end bells into structure walls from both sides to provide watertight entrances
- G. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 5 feet outside the building wall, without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Duct banks shall be tied into building walls using rebar to prevent shearing of conduit and cable. Install conduit penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
- H. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.
- I. Rodent Prevention: For all conduit(s) with cables/conductors installed provide and install stainless steel wool mesh inserted six inch (6") deep into conduit(s) and half inch (1/2") exposed at end of conduit(s) for all conduits larger than 1 inch (1").
- J. Pulling Cord: Install 100-lbf test nylon cord in empty ducts.
- K. Concrete Encased Ducts:
 - 1. Provide rigid PVC spacers to provide 3 inch minimum duct spacing.

2. Anchor ducts so as to prevent flotation when concrete is poured. Do not pour concrete until conduit installation has been approved.

- L. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in by civil engineer for pipes less than 6 inches in nominal diameter.
 1. Width: Excavate trench to minimum width consistent with stability of sides.
 2. Depth: Install top of duct bank at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 24 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
 3. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than three spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
 4. Minimum Space between Ducts: 3 inches between ducts and exterior envelope wall, 3 inches between ducts for like services, and 12 inches between power and comm ducts. Note that the center to center distance between ducts shall be 7.5 inches minimum per NFPA 70.
 5. Elbows: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment, at building entrances through floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
 - b. Stub-Ups to Equipment: Rigid galvanized steel conduit and fittings. Install insulated grounding bushings on terminations at equipment.
 6. Reinforcement: Reinforce all concrete-encased duct banks. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
 7. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
 8. Concrete Cover: Install a minimum of 3 inches of concrete cover at top and bottom, and a minimum of 3 inches on each side of duct bank.
 9. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
 - a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations or use other specific measures to prevent expansion-contraction damage.
 - b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing-rod dowels extending a minimum of 18 inches into concrete on both sides of joint near corners of envelope.
 10. Pouring Concrete: Comply with requirements of civil engineer of record. Place concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.

- M. Warning Tape: Bury warning tape approximately 12 inches above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of ductbank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

3.8 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

- A. Cast-in-Place Manhole Installation:
1. Finish interior surfaces with a smooth-troweled finish.
- B. Precast Concrete Handhole and Manhole Installation:
1. Comply with ASTM C 891 unless otherwise indicated.
 2. Install unit level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances.
 3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevations:
1. In areas subject to vehicular traffic, install plumb and level to manufacturer's instructions and ASTM C 891.
 2. In areas which are not subject to vehicular traffic, install so that manhole or handhole cover is 2 inches above the level of surrounding dirt or gravel.
 3. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch above finished grade.
 4. Where indicated, cast handhole cover frame integrally with handhole structure.
- D. Support units on a level bed of crushed pea gravel or compacted gravel.
- E. Drainage: Install 2" drains in bottom of manholes and handholes where required. Coordinate with drainage provisions indicated.
- F. Manhole Access: Circular opening in manhole roof; sized to match cover size.
1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
 2. Install ring, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to ring.
- G. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. After ducts have been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole rings after mortar has cured at least three days.

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RACEWAYS FOR ELECTRICAL SYSTEMS**

- H. Hardware: Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.
- I. Sealing: Seal around all penetrations. Provide temporary closure at terminations of ducts. Seal spare ducts and use sealing compound to withstand at least 15 psi hydrostatic pressure.
- J. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
- K. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.9 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by manufacturer.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 2 inches above finished grade.
- D. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
- E. Field cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- F. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on controlled density fill per engineer of record.
 - 1. Concrete: 3000 psi, 28-day strength with a troweled finish.
 - 2. Dimensions: Minimum 10 inches wide by 12 inches deep or per engineer of record.

3.10 SUMP PIPING

- A. Provide sump pipe and sump in high water table areas where low voltage power can be made readily available, unless waived by F&I.

3.11 GROUNDING

- A. Ground underground ducts and utility structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. Underground Structures:

- a. Handhole and Small Manholes (less than 16 square foot floor): Install two ground rods through floor in each handhole and small manhole with top protruding four inches (4") above floor.
- b. Large Manholes (greater than 16 square foot floor) and Vaults: Install four ground rods through floor in each large manhole with top protruding four inches (4") above floor. Refer to Section 260526 "Grounding and Bonding for Electrical Systems" and detail drawing "Manhole Ground Plan with Foldout."
- c. Ensure rods are copper-clad steel, 3/4-inch diameter by 10 foot minimum.
- d. Provide a ground wire ring in the underground structure, attached to wall. Ground ring attached at 24 inches (24") on center and mounted minimum 6 inches (6") above floor.
 - 1) Medium Voltage – ground wire shall be #4/0 AWG bare copper.
 - 2) Low (600V or less) Voltage – ground wire shall be #1/0 AWG bare copper.
 - 3) Airfield Lighting – ground wire (counterpoise) shall be #1/0 AWG bare copper.
- e. Ground Underground Structures (Manhole, etc) equipment and components per Manhole Grounding Plan, SK5.

2. Underground Raceways:

- a. Provide a ground wire installed above raceway(s)
 - 1) Duct banks (with 2 or more raceways)
 - a) Medium Voltage – ground wire shall be #4/0 AWG bare copper.
 - b) Low (600V or less) Voltage – ground wire shall be #1/0 AWG bare copper..
 - c) Airfield Lighting – ground wire (counterpoise) shall be #1/0 AWG bare copper.
 - 2) Individual Raceways
 - a) Airfield Lighting to base cans – ground wire (counterpoise) shall be #6 AWG solid bare copper.
 - 3) All situation not identified above provide #2 AWG stranded copper equipment ground minimum above each raceway.

3.12 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:

1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
 2. Prior to pouring any concrete, pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 6-inch-long mandrel equal to 80 percent fill of duct, with chalk covered end and inspect scoring. Replace all score-producing sections of conduit. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.13 CLEANING

- A. Cleaning: Pull brush through full length of ducts. Clean internal surfaces of handholes, manholes and vaults including sump. Repeat until mandrelling is successful.

END OF SECTION 260543

Except as noted below:

Manhole Grounding Plan

Switch Vault Details

Standard Details 260543-01 through 15