**Microsoft WAW02**

Section 26 05 43

Underground Ducts and Raceways for Electrical System Review

**Underground Ducts and Raceways for Electrical System Review**

Project Number 20\_D065

Document Number WAW02-E-SP-008

IFC Issue

Oct 2020

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | | | | | | |
|  | | | | | | |
|  | | | | | | |
|  | | | | | | |
|  | | | | | | |
| Microsoft WAW02 | | | | | | |
| Underground Ducts and Raceways for Electrical System Review | | | | | | |
|  | | | | | | |
|  | | | | | | |
|  | | | | | | |
| Project Number 20\_D065 | | | | | | |
| Document Number WAW02-E-SP-009 | | | | | | |
|  | | | | | | |
|  | | | | | | |
|  | | | | | | |
| **CURRENT ISSUE** | | | | | | |
| Issue No: | | 04 | | Issue Date: | | 30/10/2020 |
| Sign Off | | Originator: | | Checker: | | Reason For Issue: |
| Print Name: | | Nico Brits | | John Clarke | | IFC Issue |
|  | | | | | | |
|  | | | | | | |
| **PREVIOUS ISSUES (Type Names)** | | | | | | |
| Issue No: | Date: | | Originator: | | Checker: | Reason For Issue: |
| 01 | 17/08/2020 | | John Clarke | | Gary O’Keefe | 50% Review |
| 02 | 21/09/2020 | | Nico Brits | | John Clarke | 90% Review |
| 03 | 02/10/2020 | | Nico Brits | | John Clarke | IFC Issue |
|  |  | |  | |  |  |

##### Table of Contents

[1. General 4](#_Toc48652833)

[1.1. Summary 4](#_Toc48652834)

[1.2. Definitions 4](#_Toc48652835)

[1.3. References 4](#_Toc48652836)

[1.4. Submittal Documentation Requirements 4](#_Toc48652837)

[1.5. Submittals 4](#_Toc48652838)

[1.6. Site Conditions 5](#_Toc48652839)

[1.7. Quality Assurance 5](#_Toc48652840)

[1.8. Delivery, Storage and Handling 5](#_Toc48652841)

[1.9. Warranty 5](#_Toc48652842)

[1.10. Extra Materials (Not required) 5](#_Toc48652843)

[1.11. Coordination 5](#_Toc48652844)

[2. Products 6](#_Toc48652845)

[2.1. Conduit 6](#_Toc48652846)

[2.2. Non Metallic Ducts and Duct Accessories 7](#_Toc48652847)

[2.3. Precast Concrete Handholes and Boxes 7](#_Toc48652848)

[2.4. Handholes and Boxes other than Precast Concrete 8](#_Toc48652849)

[2.5. Precast Manholes 8](#_Toc48652850)

[2.6. Utility Structure Accessories 9](#_Toc48652851)

[2.7. Concrete for Duct Bank Installation 11](#_Toc48652852)

[2.8. Source Quality Control 11](#_Toc48652853)

[3. Execution 11](#_Toc48652854)

[3.1. Installation 11](#_Toc48652855)

[3.2. Underground Duct Application – Applies to Exterior Ducts as well as those Installed under Building Floor Slabs 11](#_Toc48652856)

[3.3. Underground Enclosure Application - Exterior Locations Only 12](#_Toc48652857)

[3.4. Earthwork 12](#_Toc48652858)

[3.5. Duct Installation and Design 12](#_Toc48652859)

[3.6. Installation – concrete Manholes, Handholes, and Boxes – Exterior Locations Only 15](#_Toc48652860)

[3.7. Installation Of Handholes And Boxes Other Than Precast Concrete - Exterior Locations Only 17](#_Toc48652861)

[3.8. Earthing 17](#_Toc48652862)

[3.9. Field Quality Control 17](#_Toc48652863)

[3.10. Cleaning 18](#_Toc48652864)

# General

## Summary

* + 1. Section Includes: conduit, ducts, and duct accessories for direct-buried and concrete-encased duct banks and single duct runs, handholes and boxes, and manholes.

## Definitions

* + 1. Refer to Section 26 05 00, “Common Work Results for Electrical” and Section 01 42 00, “References” for common definitions used throughout all specifications.

## References

* + 1. Refer to Section 01 42 00, “References” for common references used throughout all specifications.
    2. Refer to the following sections for related requirements:
       1. Section 07 13 26, “Self-Adhering Sheet Waterproofing”
       2. Section 08 71 00, “Door Hardware”
       3. Section 26 05 26, “Earthing and Bonding for Electrical Systems”
       4. Section 31 20 00, “Earth Moving”
       5. Section 31 50 13, “Site Trench Excavation Protection”

## Submittal Documentation Requirements

* + 1. Refer to Section 01 33 00, "Submittal Procedures" for submittal documentation requirements.

## Submittals

* + 1. Action Submittals:
       1. Product data for the following:
          1. Duct-bank materials, including separators and miscellaneous components.
          2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
          3. Accessories for manholes, handholes, and boxes
          4. Warning tape
       2. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:
          1. Duct entry provisions, including locations and duct sizes.
          2. Reinforcement details.
          3. Frame and cover design, and manhole frame support rings.
          4. Ladder details.
          5. Grounding details.
          6. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
          7. Joint details.
       3. Shop Drawings and Calculations for Underground Duct Banks: Refer to paragraph 3.5 of this section for detailed requirements.
       4. Product Certificates: For concrete and steel used in precast concrete manholes, as required by EN1917.
       5. See Section 31 20 00, “Earth Moving” for backfill materials submittal requirements
       6. Source quality-control test reports.
       7. Pulling calculations, showing pulling tension and sidewall pressure.
    2. Closeout Submittals:
       1. Field quality-control test reports.

## Site Conditions

* + 1. Refer to Section 26 05 00, “Common Work Results for Electrical” for site conditions applicable to this project.

## Quality Assurance

* + 1. Refer to Section 26 05 00, “Common Work Results for Electrical” and Section 01 40 00, “Quality Requirements” for typical quality assurance requirements.
    2. Testing Agency Qualifications: Qualified according to EN1917:2002 for testing indicated.
    3. Comply with IEC 60364.
    4. Comply with all local electrical standards.
    5. Electrical Components, Devices, and Accessories: Listed and labeled, per IEC 60364 and which is acceptable to the authority having jurisdiction, and marked for intended use.

## Delivery, Storage and Handling

* + 1. Refer to Section 26 05 00, “Common Work Results for Electrical” for typical requirements.
    2. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.
    3. Store precast concrete underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.
    4. Lift and support precast concrete units only at designated lifting or supporting points.

## Warranty

* + 1. Refer to Section 26 05 00, “Common Work Results for Electrical” for typical warranty requirements.

## Extra Materials (Not required)

## Coordination

* + 1. 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.
    2. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, trenches 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 from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Engineer.
    3. Ducts are indicative for design intent only; the GC is responsible for setting out below ground ducts and coordinating with the electrical contractor to ensure ducts are suitable for all cables identified and with the CFCI vendors to ensure co-ordination with electrical equipment.
    4. All ducts identified on the drawings shall be coordinated with the precast plank sub-contractor.
    5. All tracer wires to be coordinated with below ground services and to be installed in a separate 50mm duct unless incorporated in the marker tape or otherwise indicated. Seal tracer ducts to 15psig internal and external to duct.

# Products

## Conduit

* + 1. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:
       1. Rigiduct.
       2. Emtelle.
       3. Duraline
       4. O-Z Gedney; a unit of Emerson Industrial Automation.
       5. Polypipe
       6. Marley pipe systems
       7. Owner- approved equivalent.
    2. RMC: IEC 60981; rigid galvanized steel.
       1. Fittings and Conduit Bodies: Threaded type, steel. Do not use setscrew-type couplings, elbows, sweeps, or nipples. Provide bushings with shoulders, grounding lugs, and insulated nonmetallic throats.
    3. IMC: IEC 60981; galvanized steel.
       1. Fittings and Conduit Bodies: Threaded type, steel. Do not use setscrew-type couplings, elbows, sweeps, or nipples. Provide bushings with shoulders, grounding lugs, and insulated nonmetallic throats.
    4. RNC: IEC 61386-1; unless otherwise indicated. Construct and mark conduit for use with 90-degree C rated conductors.
       1. Fittings and Conduit Bodies: IEC 61386-1; match to conduit or tubing type and material. Construct and mark fittings for use with 90-degree C rated conductors.
    5. PVC-Coated RMC: PVC-coated rigid steel conduit.
       1. Comply with IEC 61386-1.
       2. Coating Thickness: 1 mm, minimum.
       3. Conduit shall be listed under EN 61386.
       4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 1 mm, with overlapping sleeves protecting threaded joints
    6. Fiberglass: Reinforced thermosetting resin conduit (RTRC) per IEC 61386-1.

## Non Metallic Ducts and Duct Accessories

* + 1. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:
       1. Rigiduct.
       2. Emtelle.
       3. Duraline
       4. O-Z Gedney; a unit of Emerson Industrial Automation.
       5. Polypipe
       6. Marley pipe systems
       7. Panduit
       8. Owner- approved equivalent.
    2. Duct Accessories:
       1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacing indicated while supporting ducts during concreting or backfilling.
       2. Warning Tape:
          1. Acceptable Manufacturers:

ETS Cable components

Panduit: HTDU6R-E.

Owner- approved equivalent.

* + - * 1. Permanent, bright-colored polyethylene tape.
        2. Continuous printed warning that an electric circuit is located below tape.
        3. Not less than 150 mm wide by 0.1mm thick.
        4. Compounded for permanent direct-burial service.
        5. Embedded continuous metallic strip or core.
        6. Printed legend shall indicate type of underground line.
        7. Coordinate with tracer wire as per detail in design intent drawings

## Precast Concrete Handholes and Boxes

* + 1. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be considered for incorporating into the Work include the following:
       1. Stanton Bonna - Consolis group
       2. Milton precast
       3. Greaney Concrete Products
       4. Hanson Building Products
       5. Rigiduct.
       6. Emtelle.
       7. Duraline
       8. O-Z Gedney; a unit of emerson Industrial Automation.
       9. Polypipe
       10. Marley pipe systems
       11. Owner- approved equivalent.
    2. Comply with EN 1992 for design and manufacturing processes and CE certified
    3. Comply with EN 1917 for concrete manholes and inspection chambers, unreinforced, steel fibre and reinforced.
    4. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.
       1. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing penta-head bolts. Provide five penta-head sockets to the Owner.
       2. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
       3. Cover Legend: Molded lettering, "ELECTRIC" or “COMMUNICATION,” as required.
       4. Configuration: Units shall be designed for flush burial and have closed bottom, unless otherwise indicated.

## Handholes and Boxes other than Precast Concrete

* + 1. Description: Comply with SCTE 77.
       1. Color: Grey.
       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, "ELECTRIC" or “COMMUNICATION,” as required.
       6. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
    2. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
       1. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:
          1. Armorcast Products Company.
          2. Carson Industries LLC. a division of Oldcastle Precast
          3. NewBasis.
          4. Owner- approved equivalent.
    3. Fiberglass Handholes and Boxes with Polymer Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.
       1. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include following:
          1. Armorcast Products Company.
          2. Carson Industries LLC. a division of Oldcastle Precast.
          3. Christy Concrete Products. a division of Oldcastle Precast.
          4. Synertech Moulded Products, Inc.; a division of Oldcastle Precast.
          5. Owner- approved equivalent.

## Precast Manholes

* + 1. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:
       1. Carder Concrete Products.
       2. Christy Concrete Products. a division of Oldcastle Precast.
       3. Elmhurst-Chicago Stone Co.
       4. Oldcastle Precast Group.
       5. Riverton Concrete Products; a division of Cretex Companies, Inc.
       6. Utility Concrete Products, LLC.
       7. Wausau Tile, Inc.
       8. Owner- approved equivalent.
    2. Comply with EN1992, with structural design loading as specified in Part 3 "Underground Enclosure Application" Article and with interlocking mating sections, complete with accessories, hardware, and features.
       1. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 300 mm vertically and horizontally to accommodate alignment variations.
          1. Windows shall be located no less than 150 mm from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
          2. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
          3. Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
       2. 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.
          3. Duct entrance to be arranged to allow for either the vertical or horizontal spread of conduits in the duct bank. A/E to determine the duct bank and vault design type required to minimize heating effects. See drawing E-I-01 for detailed duct entrance requirements of both square and octagonal vault arrangements.
    3. Concrete Knockout Panels: 40 to 50 mm thick, for future conduit entrance and sleeve for ground rod.
    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.

## Utility Structure Accessories

* + 1. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:
       1. Stanton Bonna - Consolis group
       2. Milton precast
       3. Greaney Concrete Products
       4. Hanson Building Products
       5. Rigiduct.
       6. Emtelle.
       7. Duraline
       8. O-Z Gedney; a unit of emerson Industrial Automation.
       9. Polypipe
       10. Marley pipe systems
       11. Owner- approved equivalent.
    2. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.
       1. Frame and Cover: Weatherproof, grey cast iron complying with EN124 and site structural specification requirements for Installation of Underground Precast Concrete Utility Structures with milled cover-to-frame bearing surfaces; diameter, 600mm. Group 2 in pedestrian ways and Group 4 in roadways/carparks. Removable cover with lockable lids required, see detail drawings.
          1. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
          2. Special Covers: Recess in face of cover designed to accept finish material in paved areas.
       2. Cover Legend: Cast in. Selected to suit system.
          1. Legend: "ELECTRIC-LV" plus manhole number as indicated on Drawings, for duct systems with power wires and cables for systems operating at 600 V and less.
          2. Legend: "ELECTRIC-HV" plus manhole number as indicated on Drawings, for duct systems with medium-voltage cables.
          3. Legend: “SIGNAL” for communications, data and telephone ducts systems.
       3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
          1. Mortar for Chimney Ring and Frame and Cover Joints: Comply with EN 998 strength M4 and site structural specification requirements for Installation of Underground Precast Concrete Utility Structures and EN 10205except for quantities less than. 600 cu. mm. where packaged mix complying with site structural specification requirements for Installation of Underground Precast Concrete Utility Structures and ISO 1461, may be used.
    3. Manhole Sump Frame and Grate: per the site structural specification requirements for Installation of Underground Precast Concrete Utility Structures .
    4. Cement Mortar used for filling lift holes, joints, patching and anchoring castings shall consist of one part Portland cement, type I, ASTM C 150, 1/4 part hydrated lime, ASTM C 206 and 2-1/2 parts clean, well-graded sand and water free of suspended matter, alkali, and containing no industrial or domestic waste.
    5. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 50 mm diameter eye, and 6 mm bolt. Working Load Embedded in 150 mm, 275 BAR Concrete: 1.47 kN/m minimum tension.
    6. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 32mm diameter eye, rated 283 N/m minimum tension.
    7. Pulling-In and Lifting Irons in Concrete Floors: 22 mm diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
       1. Ultimate Yield Strength: 4.52 kN/m shear and 6.78 kN/m tension.
    8. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 12 mm ID by 70 mm deep, flared to 32 mm minimum at base.
       1. Tested Ultimate Pullout Strength: 1.36 kN/minimum.
    9. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 12 mm bolt, 600 N/m rated pullout strength, and minimum 768 N/m rated shear strength.
    10. Cable Rack Assembly: Steel, hot-rolled galvanized, except insulators.
        1. Stanchions: T-section or channel; 57 mm nominal size; punched with 14 holes on 38 mm centers for cable-arm attachment.
        2. Arms: 38 mm wide, lengths ranging from 76 mm with 200 kg minimum capacity to 450 mm with 115 kg minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
        3. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.
    11. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.
        1. Stanchions: Nominal 915 mm high by 100 mm wide, with minimum of 9 holes for arm attachment.
        2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 76 mm with 200 kg minimum capacity to 500 mm with 115 kg minimum capacity. Top of arm shall be nominally 100 mm wide, and arm shall have slots along full length for cable ties.
    12. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 1 deg C. Capable of withstanding temperature of 150 deg C without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.
    13. Fixed Manhole Ladders: Arranged for attachment to roof or wall of manhole. Ladder and mounting brackets and braces shall be fabricated from hot-dip galvanized steel.
    14. Cover Hooks: Heavy duty, designed for lifts 6.8 N/m and greater. Two required.
    15. Backfill Materials for Vaults and Handholes: As specified in section 31 20 00 Earth Moving.
        1. Select Backfill
        2. Controlled Low-Strength Fill (slurry). CLF to be submitted and approved by Civil Engineer prior to placement as an approved alternate.

## Concrete for Duct Bank Installation

* + 1. Cast-In-Place concrete for concrete encased duct bank installation shall conform to ACI 301. Compressive Strength: 3000 psi at 28 days. Reinforcement: ASTM A 615, grade 40 or 60 deformed reinforcing bars, and ASTM A 185 for wire fabric.
    2. For inclement weather concrete installation refer to ACI 306.1 and ACI 305.1 as applicable.

## Source Quality Control

* + 1. Test and inspect precast concrete utility structures according to EN 1992.
    2. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with 27.05.43 Underground Duct Banks and Conduits. Strength tests shall be for specified tier ratings of products supplied.
       1. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012.

# Execution

## Installation

* + 1. The Exterior Electrical Pathway System will provide a distribution system for all system cabling that will enter and exit the Data Center. Exterior pathways are required to connect new or existing buildings. The pathways for a campus distribution system may include all or some of the following, maintenance holes, hand hole, innerduct, and conduits.
    2. 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.
    3. 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 from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by the Engineer.
    4. The number, size, raceway duct material and arrangement shall be as indicated on Drawings and/or as specified herein.
    5. Underground piping and conduit shall be field located by the use of the project model for GPS coordinates before backfilling. The GPS coordinates as well as elevation shall be provided at all fittings, horizontal bends, vertical bends, and at 30 meter intervals. Provide elevation at the top middle of the duct bank and include the duct bank section.
    6. For excavation safety, refer to Section 31 50 13, “Site Trench Excavation Protection.”
    7. Survey information shall be provided to owner and incorporated into the Contractor BIM model to be provided to owner for as-built location.

## Underground Duct Application – Applies to Exterior Ducts as well as those Installed under Building Floor Slabs

* + 1. Ducts for Electrical Cables Over 600 V: HDPE in sharp sand bedding, concrete-encased if indicated.
    2. Ducts for Electrical Feeders 600 V and Less: PP or uPVC in sharp sand bedding concrete-encased if indicated.
    3. Do not use aluminum conduit or fittings in direct contact with concrete.
    4. Ducts for Electrical Branch Circuits: In direct-buried duct bank, unless otherwise indicated. Conduits shall be concrete-encased under paved roadways and parking areas. Encasement shall extend [3 meters] beyond edge of such surfaces.

## Underground Enclosure Application - Exterior Locations Only

* + 1. Manholes: Precast or cast-in-place concrete.
       1. Manholes and Boxes for 600 V and Less: EN124 with milled cover-to-frame bearing surfaces; diameter, minimum of 600mm. Group 2 in pedestrian ways and Group 4 in roadways/carparks.

## Earthwork

* + 1. Excavation and Backfill: Comply with Section 31 20 00, “Earth Moving.” The use of heavy-duty, hydraulic-operated, compaction equipment is prohibited.

## Duct Installation and Design

* + 1. Ducts installed shall comply with the following fill ratio (CSA of cable as a percentage of available internal CSA of the cable duct)
       1. Ratio for 1 cable in duct 53%
       2. Raito for 2 cables in a duct 31%
       3. Ratio for 3 cables in a duct 40%
       4. If the duct has more than two 90 degree bends per pull section, subtract 15% from the total CSA of the duct for each additional bend. It is recommended that no more than two 90 degree bends be placed in a single section of cable duct.
    2. Design of underground / underslab electrical ducts shall be completed by the Contractor and approved by the A/E prior to the purchase or installation of associated raceways and cabling. The Neher-McGrath heat rise study of the proposed electrical duct bank design shall be completed, reviewed, and approved by the A/E prior to installation of any ducts in the ground. Alternatively, compliance with ERA schedules for cable ratings in underground conditions shall be accepted.
       1. The Contractor shall convene and conduct a meeting with the A/E and Microsoft data center engineers, prior to the start of the underground design to discuss requirements including feeder load and diversity factors, duct bank encasement and backfill materials, duct bank thermal analysis methodology, and related deliverables.
       2. Submit the underground design as shop drawings that include conduit layouts, sections, and supporting details.
       3. The design shall also include product data for duct bank encasement and backfill materials, including thermal resistivity properties of the materials, graphs indicated how these properties are expected to change with moisture content, and the expected steady state moisture content of the installed materials after the data center is in operation at full load. This same information shall be used in the thermal analysis study described below.
       4. The design shall include a Neher-McGrath thermal analysis study for each of the electrical power duct banks; E-Tap or Amp Calc software shall be used.
          1. Unless otherwise noted or directed by the A/E during the kick-off meeting, each conductor shall have a diversity factor of 1.0 with a continuous load equal to the maximum continuous feeder load, taking into account possible voltage drop, load imbalances, losses, and other factors that might reasonably affect the ampacity. For the site medium-voltage (MV) feeders serving the data center the total load capacity of the building at 100% loading (detailed below) shall be used to determine the feeder loading. If N+1 redundancy is part of the design then the load calculation shall be based on the maximum continuous feeder loading when operating at N redundancy. To determine total load capacity of the overall site and individual MV and Generator substation loading, design for 100 percent kW load on the generator as well as the UPS systems. This becomes the capacity defining pinch point in the design. The assumed power factor for all feeders shall be 0.98 lagging for air cooled designs and if chillers or other mechanical substations are involved then the power factor will be adjusted to 0.95 lagging on just those added mechanical buses. All conductor sizes and / or quantities shall be adjusted as necessary to ensure they can support their load without overheating.

Example load calculation for one generator substation with air cooled design: 2MW generator x 100 percent loading = 2 MW. 2 MW/0.98 PF = 2.04 MVA. 2.04 MVA/(480V x 1.73) = 2,455 amps to be used for this thermal calculation.

The above value would be extrapolated by the number of generators (N count) to determine the maximum site loading to be used in the site MV feeder thermal calculations.

Load bank feeders are the exception and they would be based on full load (kW) of the UPS or Generator involved.

* + - * 1. For conductors rated 400V and less they shall not exceed 75 degrees C and for conductors rated over 400V they shall not exceed 85 degrees C. when operated at the loading levels defined above. Soil analysis shall be used to determine the RHO value at various values of moisture content. The moisture content of the selected backfill material, and surrounding soil will assume that the heat produced by the feeders within the duct bank will cause dry-out over time. A 3 percent maximum moisture content shall be used in determining the RHO value. The only exception would be for very specific data for the site that shows that the moisture content will be maintained at higher levels around the duct bank. Exceptions will require written approval by the A/E project electrical engineer along with documentation proving this is the case.
        2. Calculation input parameters and results shall be submitted in a tabular / spreadsheet format.
        3. All calculations shall be performed by a professional engineer, licensed in the state in which the project is located and be reviewed by the A/E project electrical engineer prior to any installation work taking place.
        4. The A/E shall be responsible for coordinating an initial soil analysis and providing a site specific soil resistivity and RHO value for the project. Contractor may use these values or have additional testing performed as described above. These parameters shall be provided at the 30 percent Design Development (DD) stage.
      1. All conduits shall be identified in the shop drawings and calculations with their corresponding source and load, as indicated on the Drawings.
    1. Redundant duct bank separation: For redundant power duct banks, a minimum of 1.8 m of separation shall be maintained between the duct banks. If this is not possible due to site constrains or required crossing, then written approval from the A/E project electrical engineer shall be required. Consideration of the heating effects and impact on conductor heat rise and sizing shall also be considered in the actual separation that is required.
    2. GC shall coordinate the pre-inspection of all pits and chambers to ensure that the duct enters the chamber at 90 degrees to pit/chamber walls. Duct shall be installed to allow space for perpendicular cleating of all cables as they leave ducts.
    3. 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.
    4. Curves and Bends in Duct Bank Routing: Use 5-degree angle couplings for small changes in direction. Use manufactured elbows, both horizontally and vertically at other locations where duct bank must change direction, unless otherwise indicated. Bends shall be made using fiberglass or rigid steel or RTRC.
       1. Radius of elbows must be sufficient to meet the requirements of the allowable bending radius of the conductors being installed.
       2. Contractor to provide pulling calculations to document pulling tension and sidewall pressure.
       3. For bends less than 30 degrees, an approved field bending method is acceptable with the following requirements:
          1. Submit method to A/E and owner for approval.
          2. No open flame.
          3. No deformation of inside diameter of conduit.
    5. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions.
    6. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 254 mm on center for 127 mm ducts, and vary proportionately for other duct sizes.
       1. Begin change from regular spacing to end-bell spacing 3m 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.
    7. Building Wall Penetrations: Extend concrete encased duct banks through building exterior walls and to interior equipment.
    8. Sealing: Provide sealing for all ducts. Ducts shall be sealed with manufactured seals or plugs when installation is temporarily discontinued or not being directly worked on, and upon final completion of the work. Use mechanical duct seal (Roxtec or equal and approved) and plugs to withstand at least 15-psig hydrostatic pressure.
    9. Seal internal pop-ups with mechanical seal, ensure pullcords are accessible. Benchmark to be offered to the AE prior to roll out in all internal pop-ups.
    10. Seal external pop-ups with mechanical seal, providing a sealed solution to pull extra cables if needed in future. Seal should have a number of empty cable seal packs for future installation.
    11. If sub-ducts are deemed necessary by the GC, they shall be installed in accordance with the telecoms BOM.
    12. The contractor shall provide and install duct plugs to all empty/spare ducts. The plug shall be installed in accordance with manufacturers requirements/recommendations and shall be suitable to prevent the ingress or water in accordance with the parameters detailed herein.
    13. The contractor shall provide and install temporary duct plugs to all ducts as early as possible to minimise any risk of water or rodent ingress. Temporary duct seals shall be installed following duct installation schedule and not cable install.
    14. Earth rod will be separate to chamber/pit, a link from the earth bar will be linked to the chamber. The earthing conductor shall be sealed to withstand the pressure of 15-psig.
    15. Sealing of ducts in pre-cast or as-built pits/chambers: The GC shall install seals to all existing ducts coordinate a Surface mounted solution for sealing duct penetrations into the pits with a face fix seal solution to the chamber/pit wall. The contractor shall coordinate the installation with the seal manufacturers.
    16. Sealing of ducts for cast in situ pits/chambers: The GC shall coordinate a duct seal insert to provide a cast in concrete solution. A cast puddle-flange fixing, shall be installed within the chamber wall, which will integrate with the site installed duct for a watertight solution.

1. Roxtec knockout sleeve or equal and approved.
   * 1. Pulling Cord:
        1. Install 136 N/m test nylon cord in ducts, including spares.
        2. Identify with tags at each end the origin and destination of each empty duct and indicate same on empty or spare conduit on as-constructed drawings.
     2. Concrete-Encased Ducts: Support ducts on duct separators.
        1. Concrete used for the top pour of exterior electrical power conduits shall be dyed red.
        2. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 6 meters of duct. Secure separators to earth and to ducts to prevent floating during concreting. Field verify locations of utilities adjacent to and crossing duct bank location prior to securing separators to earth. Stagger separators approximately 152 mm between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
        3. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
           1. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.
           2. If more than one pour is necessary, terminate each pour in a vertical plane and install 20 mm reinforcing rod dowels extending 450mm into concrete on both sides of joint near corners of envelope.
        4. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
        5. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms. Field verify location of utilities adjacent to and crossing duct bank location prior to installation of imbedded supports.
        6. Depth: Unless indicated otherwise, install top of duct bank at least 600 mm below finished grade in areas not subject to deliberate traffic, and at least 760 mm below finished grade in deliberate traffic paths for vehicles, unless otherwise indicated.
        7. Stub-Ups: Use manufactured duct elbows for stub-ups at poles and equipment through the floor / grade, unless otherwise indicated. Extend concrete encasement throughout the length of the elbow. Unless otherwise noted, concealed conduit stub-ups into interior or exterior pad mounted equipment shall be made utilizing fiberglass elbows and conduits or RTRC elbows and heavy wall RTRC conduit and socket type end bells.
        8. Warning Tape: Bury warning tape approximately 300 mm above concrete-encased ducts and duct banks. Align tape parallel to and within 76 mm of the centerline of duct bank. Provide an additional warning tape for each 300 mm increment of duct-bank width over a nominal 450 mm. Space additional tapes 300 mm apart, horizontally.
     3. Underground piping and conduit to be field located by the use of the project model for GPS coordinates before backfilling. The GPS coordinates as well as elevation shall be provided at all fittings, horizontal bends, vertical bends and at 30 m intervals. Provide elevation at the top middle of the duct bank and include the duct bank section. Survey information shall be provided to owner and incorporated into the Contractor BIM model to be provided to owner for as-built location.
        1. Survey information shall be provided to engineer on a weekly basis through the construction of underground utilities

## Installation – concrete Manholes, Handholes, and Boxes – Exterior Locations Only

* + 1. Cast-in-Place Manhole Installation:
       1. Finish interior surfaces with a smooth-troweled finish.
       2. Windows for Future Duct Connections: Form and pour concrete knockout panels 38 to 50 mm thick, arranged as indicated.
       3. Cast-in-place concrete, formwork, and reinforcement are specified in Section 03 00 13, Concrete.
       4. Manholes shall be a minimum of 2500x2500mm internal dimension and a depth to suit the cable installation. Co-ordinate with the electrical contractor for confirmed pit dimensions.
    2. Precast Concrete Handhole and Manhole Installation:
       1. Comply with ASTM C 891, unless otherwise indicated.
       2. Install units 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 150mm crushed stone or gravel and compacted to same density as adjacent undisturbed earth.
       4. Manholes shall be a minimum of 2500x2500mm internal dimension and a depth to suit the cable installation. Co-ordinate with the electrical contractor for confirmed pit dimensions.
       5. Handhole cover locations shall be dimensioned in AS BUILT drawings.
    3. Elevations:
       1. Manhole Roof: Install with rooftop at least 380 mm below finished grade.
       2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 25 mm above finished grade.
       3. Install handholes with bottom below the frost line.
       4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 25 mm above finished grade.
       5. Where indicated, cast handhole cover frame integrally with handhole structure.
    4. 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 chimney, constructed of precast concrete collars and rings to support frame and cover and to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney.
    5. Waterproofing: Apply waterproofing to exterior surfaces of manholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Section 07 13 26, Self-Adhering Sheet Waterproofing. After ducts have been connected and grouted, and before backfilling, waterproof joints and connections and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.
    6. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.
    7. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
    8. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 100 mm for manholes and 50 mm for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.
    9. Warning Sign: Install "Confined Space Hazard" warning sign on the inside surface of each manhole cover.
    10. Provide at least two feet of crushed rock select backfill with less than 5 percent passing the 200 sieve under each vault to facilitate drainage. Level vault.
    11. Initial compacted backfill adjacent to vault using compacted Select Backfill (crushed stone) Materials up to an elevation to the bottom of duct banks. After installation of duct bank install remaining compacted fill to be install up to below bottom of road base materials or one foot below finish grade if not in road ways.

## Installation Of Handholes And Boxes Other Than Precast Concrete - Exterior Locations Only

* + 1. 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 the manufacturer.
    2. Unless otherwise indicated, support units on a level bed of 150 mm crushed stone or gravel, graded from 12 mm sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
    3. Elevation: In paved areas and trafficways, set so cover surface will be flush with finished grade. Set covers of other handholes 25 mm above finished grade.
    4. Install handholes and boxes with bottom below the frost line.
    5. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.
    6. Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

## Earthing

* + 1. Ground underground ducts and utility structures according to Section 26 05 26, “Earthing and Bonding for Electrical Systems” and Drawings.

## Field Quality Control

* + 1. Refer to the following Specifications:
       1. Section 26 08 00, “Electrical Systems Testing and Commissioning.”
       2. Section 26 08 13, “Electrical Systems Pre-Functional Checklist and Start-ups.”
       3. Section 26 08 16, “Electrical Systems Functional Performance Tests.”
    2. 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. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
       3. Test manhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 26 05 26, “Grounding and Bonding for Electrical Systems.”
    3. Correct deficiencies and retest as specified above to demonstrate compliance.

## Cleaning

* + 1. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

END OF SECTION