

SECTION 16200CP - ELECTRICAL POWER

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. Underground ducts shall be PVC schedule 40 minimum.
- B. All underground duct banks shall contain at least one spare duct.
- C. Duct banks shall contain a minimum of two conduits.
- D. Duct banks under non-traffic areas shall be encased in a minimum of 3" of sand.
- E. Duct banks under areas subject to vehicle traffic and where otherwise required or directed shall be encased in a minimum of 3" and a maximum of 6" of concrete. In oversized trenches, pour shall be neatly formed or contained by backfill.

PART 2 – UNDERGROUND SYSTEMS

2.1 UNDERGROUND RACEWAYS

- A. Application - Provide the following installation methods as a minimum unless otherwise approved in writing by Brown University Project Manager:
 - 1. Conductors over 600 volts - concrete encased PVC Schedule 40 raceways.
 - 2. Electric service entrance conductors - concrete encased PVC Schedule 40 raceways.
 - 3. Under building - direct buried PVC Schedule 40 raceways, except over 600 volts and conduits within five feet of, or through, foundations or grade beams shall be rigid steel conduits.
 - 4. 480/277 volt conductors - direct buried PVC Schedule 40 raceways.
 - 5. 208/120 volt conductors - direct buried PVC Schedule 40 raceways.
 - 6. Site lighting circuits - direct buried PVC Schedule 40 raceways.
 - 7. Security circuits - direct buried PVC Schedule 40 raceways.
 - 8. Under parking lots - direct buried PVC Schedule 40 raceways.
 - 9. Under roadways - direct buried PVC Schedule 40 raceways concrete encased.
 - 10. Telephone Service - direct buried PVC Schedule 40 raceways.
 - 11. CATV Service - direct buried PVC Schedule 40 raceways.
 - 12. Fire Alarm Service - direct buried PVC Schedule 40 raceways.
 - 13. Risers to ten feet above ground - rigid steel conduit.
 - 14. Sweeps and bends from underground - rigid steel conduit.
 - 15. In slabs - only where specifically indicated as allowed on Drawings or in Specifications. Type of conduit shall be as indicated above. Maximum

- size and location shall be as allowed in writing by the Structural Engineer and per the American Concrete Institute Standards.
16. Notify the Structural Engineer and get approval in writing for penetrations through masonry over five inches (127mm) in any direction and for multiple openings under five inches (127mm) within 39 inches (1m) of each other.
- B. The duct system shall consist of round bore raceways. The number and type of raceways in the duct shall be as indicated in the specifications and on the Drawings. Duct lines shall be laid to a minimum grade of four inches (100mm) per one hundred feet (30m). Grade (pitch) may be from one manhole to the next, or both ways from a high point between manholes, depending on contour of the finish grade, so that all ducts shall empty out into the manholes. Ensure no water egress into building by sloping conduits entering building down away from building. Duct lines shall be installed so that the top of raceway is not more than thirty inches (760mm) below finished grade and not less than eighteen inches (460mm), except twenty-four inches (610mm) in vehicular traffic areas, below finished grade at the high points.
- C. Changes in direction of runs exceeding a total of ten degrees either vertically or horizontally, shall be accomplished by long sweep bends (in five degree increments) having a minimum radius of curvature of twenty-five feet (7.6m), except that manufactured bends may be used at ends of short runs of one hundred feet (30m) or less, and then only at, or close to, the end of the run. The long sweep bends may be made up of one or more curved or straight sections or combinations thereof. Bends shall have a minimum radius of ten times the conduit diameter.
- D. Where it is necessary to cut the tapered end on a piece of conduit at the site, the cut and/or taper shall be made with a special tool or a lathe, so that the new taper matches the taper of the particular conduit being used.
- E. Each single raceway of the duct bank shall be separated. Separators or spacing blocks shall be made of concrete, plastic or other suitable non-metallic, non-decaying material placed on not greater than four foot (1200mm) centers.
- F. All raceways in the duct lines shall be securely anchored with non-metallic ties to prevent any movement during the pouring and spreading of concrete or backfill.
- G. All non-metallic conduits shall be handled and stored in such a manner as to avoid warping, cracking or deterioration. Provide solvent weld connections.
- H. Where installed under the building support raceways from the building slab above at six foot (2m) maximum intervals.

- I. Backfill: The earth cover shall be void of all objects over two inches (50mm) in any direction or decomposable material. Provide six inches (150mm) of sand above and below direct buried (non-concrete encased) raceways or conductors.
- J. Provide detectable tape six inch (150mm) wide polyethylene/metallic warning tape twelve inches above the entire length of underground raceway and cables, including under buildings.
- K. For rigid steel conduit for risers and sweeps from underground including at service poles, transformers, equipment and through concrete slabs. Bond to ground. Provide expansion fittings with four inch (100mm) minimum movement between exit at ground and fixed terminus. Include bonding jumpers and sufficient cable slack for the required movement. Set expansion fitting per Manufacturer's recommendations for the ambient temperature at the time of installation.
- L. Provide expansion fitting on risers from underground to compensate for any lifting or settling due to frost heaves.
- M. Spare raceways shall be plugged and sealed watertight at all manholes, handholes, buildings, and structures.
- N. Raceways with cables installed within shall be sealed watertight and gastight with appropriate fitting.
- O. Seal between raceways and wall or floor where raceways enter the building using appropriate fittings.
- P. Coordinate with other work including site, utility and landscaping work, electrical raceway and wiring work as necessary to interface installation of underground raceways, vaults, manholes and handholes with other work.
- Q. Coordinate and verify that concrete work is performed as indicated herein and on the Drawings. All concrete installed shall be monolithic, laid continuously until complete. If it is impossible to have a monolithic installation, the end of the concrete duct bank installation shall be sloped at a 30 degree angle and shall have No. 4 rebar on twelve inch (300mm) centers and three inches (76mm) of cover, installed around the perimeter of the ductbank to tie into the next pour.
- R. Where indicated or required, underground raceways shall be encased in a concrete envelope. There shall be a minimum of four inches (100mm) of concrete on all sides and three inches (75mm) between raceways.
- S. Raceway joints in concrete encasement may be placed side by side horizontally, but shall be staggered at least six inches vertically (150mm).

- T. Underground raceways crossing over pipelines or under areas subject to high vehicular traffic shall be encased in a steel reinforced concrete envelope. There shall be a minimum of four inches (100mm) of concrete on all sides and three inches (75mm) between raceways. Steel reinforcing shall consist of No. 4 steel rod spaced twelve inches on center each way, top and bottom and extend for four feet (1220mm) beyond the affected area on each side.

2.2 UNDERGROUND STRUCTURES

- A. Vaults, manholes and handholes shall be installed approximately where indicated. The exact location of each manhole shall be determined after careful consideration has been given to the location of other utilities, grading, and paving. The locations shall be approved by the Architect before installation of the manhole is started
- B. Handholes shall be set on six inches (150mm) of crushed stone.
- C. Manholes shall be set on twenty-four inches (610mm) of crushed stone.
- D. Where raceways enter vaults, manholes, or handholes, terminate raceway with end bell flush with wall.
- E. Duct lines shall enter the manhole through a square or rectangular opening of suitable dimensions provided in the walls. Where openings are provided for the entrance of duct lines, the space between ducts and between ducts and walls shall be caulked tight with lead wool.
- F. Provide brick or masonry chimney to raise opening of manhole or handhole up to finish grade level.
- G. The top of covers shall be flush with the finished surface of the paving. In unpaved areas, the top of covers shall be approximately 1/2 inch (13mm) above the finished grade. Where existing grades that are higher than finished grades are encountered, provide frame to elevate temporarily the cover to existing grade level.
- H. Place precast concrete sections as required. Use epoxy bonding compound where steps are mortared into unit walls. Install rubber joint gasket, complying with ASTM C 433, at joints between sections. Alternately apply bituminous mastic coating at joints between sections.
- I. Electric Manholes: Cables shall be trained in manholes and securely supported from walls by cable racks equipped with adjustable hooks and insulators.
- J. Cable-pulling support shall be installed in the wall opposite each duct line entrance. The cable-pulling support shall penetrate the wall and be bolted with a

metal plate on the other side. Cable-pulling support and bolts shall be stainless steel.

- K. Provide portable cable pulling supports in existing manholes for the Installer's use during installation. Condition of any existing pull supports is unknown.
- L. Provide equipment grounding and bonding connections for exposed metal parts in vaults, manholes and handholes as indicated. Tighten connections to comply with tightening torques specified in UL Std 486A to assure permanent and effective grounds.
- M. Upon completion of installation of grounding connections for vaults, manholes and handholes, test resistance-to-ground with resistance tester. Provide additional rods to ensure a 25 ohm ground at manhole.

2.3 UNDERGROUND WIRING

- A. Direct buried conduits and cables shall be installed with a minimum cover of 24 inches. There shall be six inches of sand under and twelve inches over the cables. The earth cover backfill shall be void of all objects over two inches in any direction or decomposable material. Conduit bushings shall be used where direct buried cables enter conduit system.
- B. All splices and terminations shall be made up by qualified and certified cable splicers pre-approved by the Architect. Procedures and materials shall be in strict accordance with recommendations of the Cable Manufacturer and as defined in the contract specifications. A copy of the recommendations shall be furnished to the Architect for review.
- C. Splicing and terminating materials shall be purchased in sealed moisture proof packages. Packages shall not be opened until the particular splice or termination is to be made. Care shall be taken to exclude moisture or voids from any splice. Connectors and lugs shall be of the heavy cast copper solderless compression type and shall be capable of accepting two 20 ton compressions. All large splices and terminations shall be built up before applying tape with electrical insulating putty to eliminate both sharp edges and voids. Splices between cables shall be staggered whenever possible.
- D. Cables to be spliced or terminated shall be trained and racked into their final positions before any cable is cut. Ends of cables to be spliced shall be cut so that they butt squarely together at the centerline of the splice.
- E. When a cable is opened for splicing or terminating, the work of splicing or terminating shall proceed immediately and continue uninterrupted until the splice or termination is completed, including any sealing required.

- F. Splices in jacketed cable shall be tapped sufficiently after completion of the splice to provide a protective jacket equal in all respects to the original cable jacket.
- G. Shielding shall be continued throughout splices. Terminations of shielded cables shall be equipped with stress cones. Grounding conductors in the interstices of cables shall be continued through splices. Outdoor exposed terminations in rubber-insulated shielded cables shall be equipped with rain shields. Connections to insulated buses shall be completely taped, including portions of buswork left exposed for connections.
- H. Proper supports shall be provided at each splice.
- I. Splices, when allowed, shall only be installed in handholes or manholes.
- J. All pulling-in shall be done by use of factory installed pulling eyes and approved power units (push and pull).
- K. Where pulling eyes are installed in the field, they shall be attached to all conductors which make up the cable, with suitable provisions made to protect the end or ends of the cable sheath from peeling or slipping.
- L. The pulling cable shall be attached to a power winch of sufficient size to allow for a continuous pull of cable after the cable has entered the conduit. The mechanical stress placed upon the cable during installation shall not be such that the cable is excessively twisted, stretched or flexed, and tension shall not exceed 90 percent of manufacturer's recommendations. Tension shall be measured by a dynamometer (strain gauge) on all cables. Hydraulic pressure gauges are not acceptable. Use a highest tensile indicating dynamometer. The dynamometer shall be used while pulling the cables to indicate the pulling tension on the cable and shall have a maximum tensile indicator, which shall be sealed to prevent resetting. When more than one cable pull is to be made, a record shall be made and the dynamometer may be reset in the presence of the Owner's Representative who shall sign the recorded values of each pull. Pulling tension at no time shall exceed the manufacturer's recommendations. Replace cables that exceed the manufacturer's recommended pulling tensions during installation.
- M. The length of cable left in manholes shall be sufficient to allow for racking the cable the long way around, testing and splicing. All splices shall be located between cable supports. Cables shall be offset when entering manholes so that when cable is racked in place in the manhole the cable is able to move in and out of the manhole, at the bell, due to contraction and expansion. Cables shall be trained in manholes and supported from cable racks.
- N. 601 volts and higher voltage cable splices and terminations shall be made only by qualified and certified cable splicers in strict accordance with the recommendations of the cable manufacturer and this specification. The qualifications shall consist of evidence to satisfy the Architect that each cable

splicer has worked as a journeyman in his trade for the past ten years, continuously. A list of jobs, types of cable and voltage levels worked on during this period must be supplied as the required evidence. A notarized certificate shall be submitted from the Splice Manufacturer for each cable splicer. A sample splice shall be performed for the Owner and Architect prior to any field splices.

- O. When 601 volts and higher voltage splices and terminations are completed and before the cable is placed in service, the cable shall be tested in accordance with ICEA Standard S-66-524 including a shield continuity test by ohmmeter method, an insulation test using a megohm meter and a DC high-potential test per NETA standards and recommendations.
- P. For 601 volts and higher voltages, the metallic shielding tape and the semi-conducting tape of all primary cables shall terminate in a stress cone. The cable shall terminate in a stress cone. The cable manufacturer's recommendations shall be forwarded in making of all stress cones, terminations and splices. The metallic shielding tape shall encase all splices so that the shielding is continuous between the two spliced cables. Stress cones may be prefabricated or field made by experienced installers.
- Q. For 601 volts and higher voltages, arc-proofing shall be provided around all cables where exposed in manholes, switchgear, substations or boxes by qualified workmen. Arc-proofing shall consist of two half-lapped, spirally wrapped layers of arc-proofing tape, held in place at eighteen inch (460mm) intervals with Scotch Brand 99 Hi-Temp Plastic tape.
- R. Cable shielding shall be grounded at all terminations and splices by means of No. 1/0 extra flexible copper connection in a manner recommended by the manufacturer of the cable.
- S. Effective ground connections shall be provided for all cable sheaths and shielding at each splice or termination. Grounding conductors shall be grounded to the grounding bus in switchgear, power switching centers and similar locations.
- T. All cables shall be tagged where they terminate, splice, tap, enter and leave vaults, manholes, handholes, switchgear, substations or boxes. Tags shall be made of non-ferrous metal or fiber and shall be approximately 1-1/4 inch (32mm) square and 3/32 inch (2.4mm) thick. The marking shall identify the number and size of conductors in the cable, date and manufacturer circuit number, voltage and phase in minimum 1/4 inch (6.4mm) indented lettering. The tags shall be fastened to the cable with non-ferrous metal bands approximately 3/8 inches (9.5mm) wide.
- U. Below grade tags shall be made of 1/8 inch (3.2mm) thick sheet lead. They shall be approximately 3 inch x 3 inch (75 by 75mm) in size and punched for insertion of No. 12 AWG bare copper wires for binding to cables. Markings shall be clearly and legibly die-stamped on the tags in 1/4 inch (6.4mm) letters using cable designations as provided in contract specifications, or Drawings, or as directed by

the Architect. Tags shall also show number and size of conductors in the cable, date, manufacturer, feeder number and phase.

- V. All medium voltage cable insulation shall be tested after installation. Tests shall be with D.C. voltage and shall not be less than eighty percent of factory test voltage. A plot of leakage current versus voltage shall be made and submitted to the Architect. The time span per test per cable shall be in accordance with ICEA and NETA standards.

2.4 UNDERGROUND SYSTEMS

- A. Manholes and handholes shall be precast concrete of size indicated on drawings and rated for Class H-20 wheel loading in accordance with AASHTO-HS-20-44 Standard Specifications for Highway Bridges and required strength as established by ASTM A79, Grade 60. Sections and openings at top shall be located in the center and shall be 30 inches in diameter (minimum). Manholes and Handholes shall meet the requirements and be approved by the Utility Company. Provide spare knockout access holes in all sides, pulling/lift supports, sump pit, vertical embedded continuous slot inserts, reinforced concrete and penta-head bolts.
 - 1. Minimum nominal inside dimensions shall be; Manholes 7'-0" H x 8'-0" W x 8'-0L, Handholes 2'-9" H x 3'-2" W x 4'-6" L, or as indicated on the Drawings.
 - 2. Frames and covers shall be heavy-duty cast iron with machined bearing surfaces suitable for truck loading. Frame and cover shall weigh at least 750 pounds and shall provide at least 30" opening. Covers shall be indented, solid top, with two drop handles. ELECTRIC or TELEPHONE, as appropriate, shall be cast on upper side of each cover. Aluminum covers or equal strength, properly protected against corrosion may be provided instead of cast iron.
 - 3. Hardware shall be galvanized steel. Cable racks shall be heavy-duty with adjustable arms, and free-moving porcelain saddle insulators. Provide pulling-in irons opposite initial conduit openings. Insulators shall be made of high glazed porcelain.
 - 4. Provide copper clad steel ground rod in each module. Connect non-current-carrying metal parts in manholes, including metallic sheaths of cables, to ground rod with bare copper ground conductor.
 - 5. Provide cast iron sump frame and cover for each manhole. Provide one 10' long, 12" wide, portable manhole ladder with rungs 12" apart.
- B. Deliver frames and covers to the site unpainted and, after acceptance, paint with two coats of asphalt paint.

- C. Raceways shall be non-metallic conduit installed with purpose made PVC spacers as manufactured by Underground Devices and encased in 2500 psi reinforced concrete unless otherwise indicated on the Drawings or herein specified. Material shall be as specified under Raceways.

PART 3 - EXECUTION

3.1 SHOP DRAWINGS

- A. Submit shop drawings for underground systems, showing raceway types and sizes, locations, and elevations for horizontal runs. Include details of underground structures, accessories, fittings and connections. Equip and protect factory-fabricated vaults, manholes and handholes to prevent damage, including chipping and cracking during transportation, storage and handling. Do not install damaged units. Replace, and remove damaged units from project site.

END OF SECTION