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**SECTION 02230 – SITE PREPARATION AND TREE PROTECTION****PART 1 - GENERAL**

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

## 1.2 SUMMARY

- A. Section includes general protection and pruning of existing trees and plants that are affected by execution of the Work, whether temporary or permanent construction.
- B. Related Sections:
  - 1. Division 02 Section "Site Clearing" for removing existing trees and shrubs.

**PART 2 - PRODUCTS**

## 2.1 MATERIALS

- A. Organic Mulch: Free from deleterious materials and suitable as a top dressing for trees and shrubs, consisting of one of the following:
  - 1. Type: Shredded hardwood bark.
  - 2. Size Range: 3 inches maximum, 1/2 inch minimum.
  - 3. Color: Natural.
- B. Protection-Zone Fencing: Fencing fixed in position and meeting the following requirements.
  - 1. Chain-Link Protection-Zone Fencing: Polymer-coated galvanized-steel fencing fabricated from minimum 2-inch opening, 0.148-inch-diameter wire chain-link fabric; with pipe posts, minimum 2-3/8-inch-OD line posts, and 2-7/8-inch-OD corner and pull posts with 0.177-inch-diameter top tension wire] and 0.177-inch-diameter bottom tension wire; with tie wires, hog ring ties, and other accessories for a complete fence system.
    - a. Height: 6 feet.
- C. Protection-Zone Signage: Shop-fabricated, rigid plastic or metal sheet with attachment holes prepunched and reinforced; legibly printed with nonfading lettering and as follows:
  - 1. Size and Text: As shown on Drawings.
  - 2. Lettering: 3-inch-high minimum.

**END OF SECTION – 02230**

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**SECTION 02621 – SUBDRAINAGE FOR LANDSCAPE APPLICATIONS****PART 1 - GENERAL**

## 1.1 RELATED DOCUMENTS

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

## 1.2 SUMMARY

- A. The work of this section consists of furnishing and installing subsurface drains in planting and hardscape areas using trench drains, slot drains, perforated drain lines, granular fill material, drainage board, and synthetic filter fabric.

**PART 2 - PRODUCTS**

## 2.1 ATRIUM DRAIN IN PLANTING

- A. Model 78 four inch round atrium drain. Color: black. NDS, website: [www.ndspro.com](http://www.ndspro.com) telephone: 888-825-4716.

## 2.2 FLUSH LANDSCAPE DRAIN IN LAWN

- A. Model 50 six inch round drain. Color: green. NDS, website: [www.ndspro.com](http://www.ndspro.com) telephone: 888-825-4716.

## 2.3 DRAIN LINES AND PERFORATED DRAIN LINES

- A. Schedule 40 PVC double wall solid pipe. Pipe, manufactured from virgin, low filler cell class PVC resin (12454 per ASTM D1784). Pipe shall be Contech A-2000 as manufactured by Contech construction Products, Inc, Chicago IL Phone 630 573 1110, [www.contech-cpi.com](http://www.contech-cpi.com). All fittings, "T", "Y", end caps, and splices shall be compatible fittings by the same manufacturer. Size - 4" diameter.
- B. Schedule 40 PVC double wall perforated pipe. Pipe, manufactured from virgin, low filler cell class PVC resin (12454 per ASTM D1784). Pipe shall have slots on the bottom quadrant of the pipe of 1-1/16" long by .031" wide at .413 on center. Pipe shall be Contech A-2000 as manufactured by Contech construction Products, Inc, Chicago IL Phone 630 573 1110, [www.contech-cpi.com](http://www.contech-cpi.com). All fittings, "T", "Y", end caps, and splices shall be compatible fittings by the same manufacturer. Size - 4" diameter.

## 2.4 RISER SLEEVES

- A. Schedule 40 P.V.C. plastic non-perforated pipe size as indicated on the drawings. All caps, "T", "Y", and end caps shall be compatible and made by the same manufacturer.

## 2.5 CLEANOUT

- A. Cast iron clean out ferrule with black ABS plastic plug. Model Joasam #58190. Apply water proof grease on plug threads.

## 2.6 TAPE

- A. Plastic 3" wide, polyethylene tape, 3M #3939.

## 2.7 DRAINAGE AGGREGATE

- A. Coarse aggregate meeting the requirements of AASHTO M 43 Size 57 when tested in accordance with AASHTO T27 omitting AASHTO T11 or washed pea stone gravel.

## 2.8 COARSE SAND

- A. Coarse concrete sand, ASTM C-33 Fine Aggregate, with a Fines Modulus Index of 2.8 and 3.2. Sands shall be clean, sharp, natural sands free of limestone, shale and slate particles.

1. Provide the following particle size distribution:

<u>Sieve</u>	<u>Percent Passing</u>
3/8" (9.5mm)	100
No 4 (4.75mm)	95-100
No 8 (2.36mm)	80-100
No 16(1.18mm)	50-85
No30 (.60mm)	25-60
No50 (.30mm)	10-30
No100 (.15mm)	2-10

## 2.9 DRAINAGE BOARD

- A. Basis of Design: Three-dimensional, non biodegradable plastic material with filter fabric layer. Drainage board is designed to effectively conduct water to the drain outlet. Core thickness 0.4"-1.5" as indicated. Manufactured by BASF Construction Chemicals, LLC – Building Systems, Shakopee, MN, 800-433-9517; LiveRoof, LLC, P.O. Box 533 Spring Lake, MI, phone (800) 875-1392 or approved equal.
- B. Or as recommended by waterproofing manufacturer and approved by landscape architect.

## 2.10 FILTER FABRIC

- A. Woven monofilament geotextile of 100% high-tenacity, monofilament polypropylene yarns with grab strength 255 x 275 lbs., grab elongation 15%, Mullen burst strength 420 psi, percent open area 20%-30%, apparent opening size US standard sieve 20 - 30, water flow rate 200 gpm/sf. Filter fabric shall be delivered in 12 feet wide rolls min. Filter Fabric shall be 'Carthage 30' as manufactured by Carthage Mills, Cincinnati, OH. or approved equal.

**END OF SECTION 02621**



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**SECTION 02870 – EXTERIOR SITE FURNISHINGS**

**PART 1 - GENERAL**

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
  - 1. Tables and Chair – Type 1
  - 2. Trash Receptacles

**PART 2 - PRODUCTS**

2.1 TABLES AND CHAIR – TYPE 1

- A. Product: TBD

2.2 TRASH RECEPTACLES

- A. Manufacturer: TBD
- B. Product: TBD

**END OF SECTION – 02870**

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**SECTION 02910 – PLANT PREPARATION****PART 1 – GENERAL****1.1 SUMMARY**

- A. The scope of work includes all labor, materials, tools, supplies, equipment, facilities, transportation and services necessary for, and incidental to performing all operations in connection with furnishing, delivery, and installation of Planting Soil and /or the modification of existing site soil for use as Planting Soil, complete as shown on the drawings and as specified herein.
  
- B. The scope of work in this section includes, but is not limited to, the following:
  - 1. Locate, purchase, deliver and install Imported Planting Soil and soil amendments.
  - 2. Harvest and stockpile existing site soils suitable for Planting Soil.
  - 3. Modify existing stockpiled site soil.
    - a. Modify existing site soil in place for use as Planting Soil.
    - b. Install existing or modified existing soil for use as Planting Soil.
  - 4. Locate, purchase, deliver and install subsurface Drain Lines.
  - 5. Fine grade Planting Soil.
  - 6. Install Compost into Planting Soils.
  - 7. Clean up and disposal of all excess and surplus material.

**END OF SECTION 02910**

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**SECTION 02920 – LAWNS AND GRASSES****PART 1 - GENERAL**

## 1.1 RELATED DOCUMENTS

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

## 1.2 SUMMARY

- A. Section Includes:
  - 1. Sodding.

**PART 2 - PRODUCTS**

## 2.1 TURFGRASS SOD

- A. Turfgrass Sod: Certified, Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture that is strongly rooted and capable of vigorous growth and development when planted.
- B. Turfgrass Species: Sod of grass species as follows, with not less than 85 percent germination, not less than 95 percent pure seed, and not more than 0.5 percent weed seed:
  - 1. Full Sun: Kentucky bluegrass (*Poa pratensis*), a minimum of three cultivars.
  - 2. Sun and Partial Shade: Proportioned by weight as follows:
    - a. 50 percent Kentucky bluegrass (*Poa pratensis*).
    - b. 30 percent chewings red fescue (*Festuca rubra* variety).
    - c. 10 percent perennial ryegrass (*Lolium perenne*).
    - d. 10 percent redtop (*Agrostis alba*).
  - 3. Shade: Proportioned by weight as follows:
    - a. 50 percent chewings red fescue (*Festuca rubra* variety).
    - b. 35 percent rough bluegrass (*Poa trivialis*).
    - c. 15 percent redtop (*Agrostis alba*).

**END OF SECTION 02920**

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## **SECTION 02930 - PLANTING**

### **PART 1 - GENERAL**

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Plants.
  - 2. Tree stabilization.
  - 3. Tree-watering devices.

### **PART 2 - PRODUCTS**

#### 2.1 PLANT MATERIAL

- A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
  - 1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch (19 mm) in diameter; or with stem girdling roots are unacceptable.
  - 2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
- B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Landscape Architect, with a proportionate increase in size of roots or balls.
- C. Plants shall have outstanding form; symmetrical, heavily-branched with an even branch distribution, densely foliated and/or budded, and a strong, straight distinct leader where this is characteristic of the species. Plants shall possess a normal balance for the



species between height and spread. The Landscape Architect shall be the final arbiter of acceptability of plant form.

- D. Provide healthy, vigorous stock, grown in a recognized nursery in accordance with good horticultural practice and free of disease, insects, eggs, larvae, and defects such as knots, scrapes, broken or split branches, fresh limb cuts, sunscald, injuries, abrasions, or disfigurement. All graft unions shall be completely healed, free of extreme succulence.
- E. All trees and shrubs shall be dug prior to leafing out (bud break) in the spring or when plants have gone dormant in the fall except for the following species, which are only to be dug prior to leafing out in the Spring:
1. Alnus species
  2. Betula species
  3. Carpinus species
  4. Celtis species
  5. Cercidiphyllum species
  6. Cornus species
  7. Crataegus species
  8. Fagus species
  9. Halesia species
  10. Ilex opaca species
  11. Koelreuteria paniculata
  12. Larix species
  13. Liquidambar species
  14. Liriodendron species
  15. Malus – in leaf
  16. Nyssa sylvatica
  17. Ostrya virginiana
  18. Populus species
  19. Prunus – all stone fruits
  20. Pyrus species
  21. Quercus—all oaks except Q. palustris
  22. Salix – weeping varieties
  23. Syringa reticulata
  24. Taxodium distichum
  25. Tilia tomentosa varieties
  26. Ulmus species
  27. Viburnum lentago
  28. Zelkova species

Where project schedule does not permit digging at the appropriate time the contractor shall be responsible for sourcing above-ground material. Above-ground material shall be subject to the same standards for quality and warranty.

- F. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

- G. Labeling: Label each plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant.
- H. If formal arrangements or consecutive order of plants is indicated on Drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.
- I. Annuals and Biennials: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery and that are in bud but not yet in bloom.

## 2.2 FERTILIZERS AND MYCORRHIZA

- A. Planting Soil Supplements (For All Trees, Shrubs, Perennials, Groundcovers, Vines and Annual Bedding Plants):
  - 1. Product: Assure 5-5-5 with Mycorrhiza or approved equivalent.
  - 2. Application Rate: By application type per Manufacturer.
  - 3. Contact: [www.assurefertilize.com](http://www.assurefertilize.com).
- B. Planting Tablets: Tightly compressed chip-type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.
  - 1. Size: 21-gram tablets.
  - 2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

## 2.3 MULCHES

- A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:
  - 1. Type: A blend of 50% Shredded Hardwood Bark Fines and 50% Pine Bark Fines.
  - 2. Size Range:  $\frac{3}{4}$ " for both Shredded Hardwood Bark Fines and Pine Bark Fines.
  - 3. Color: Natural.
  - 4. Installation Depth:
    - a. Tree and Shrubs: 3 inches
    - b. Ornamental Grasses: 2 inches
    - c. Perennials: 2 inches
    - d. Groundcover: 2 Inches
- B. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through a 1-inch (25-

mm) sieve; soluble-salt content of 2 to 5 dS/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

1. Organic Matter Content: 50 to 60 percent of dry weight.
2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

## 2.4 WEED-CONTROL BARRIERS

- A. Nonwoven Geotextile Filter Fabric: Polypropylene or polyester fabric, 3 oz./sq. yd. (101g/sq. m) minimum, composed of fibers formed into a stable network so that fibers retain their relative position. Fabric shall be inert to biological degradation and resist naturally encountered chemicals, alkalis, and acids.
- B. Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, 4.8 oz./sq. yd. (162 g/sq. m).

## 2.5 PESTICIDES

- A. General: Pesticide registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
- B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
- C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

## 2.6 TREE-STABILIZATION MATERIALS

- A. Trunk-Stabilization Materials:
  1. Upright and Guy Stakes: Rough-sawn, sound, new hardwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal (38-by-38-mm actual) by length indicated, pointed at one end.
  2. Wood Deadmen: Timbers measuring 8 inches (200 mm) in diameter and 48 inches (1200 mm) long, treated with specified wood pressure-preservative treatment.
  3. Flexible Ties: Wide rubber or elastic bands or straps of length required to reach stakes or compression springs.
  4. Guys and Tie Wires: ASTM A 641/A 641M, Class 1, galvanized-steel wire, two-strand, twisted, 0.106 inch (2.7 mm) in diameter.
  5. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.

6. Guy Cables: Five-strand, 3/16-inch- (4.8-mm-) diameter, galvanized-steel cable, with zinc-coated turnbuckles, a minimum of 3 inches (75 mm) long, with two 3/8-inch (10-mm) galvanized eyebolts.
7. Flags: Standard surveyor's plastic flagging tape, white, 6 inches (150 mm) long.
8. Proprietary Staking-and-Guying Devices: Proprietary stake or anchor and adjustable tie systems to secure each new planting by plant stem; sized as indicated and according to manufacturer's written recommendations.

B. Root-Ball Stabilization Materials:

1. Upright Stakes and Horizontal Hold-Down: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal (38-by-38-mm actual) by length indicated; stakes pointed at one end.
2. Wood Screws: ASME B18.6.1.
3. Proprietary Root-Ball Stabilization Devices: Proprietary at- or below-grade stabilization systems to secure each new planting by root ball and that do not encircle the trunk; sized according to manufacturer's written recommendations unless otherwise indicated.

C. Palm Bracing: Battens or blocks, struts, straps, and protective padding.

1. Battens or Blocks and Struts: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, 2-by-4-inch nominal (38-by-89-mm actual) by lengths indicated.
2. Straps: Adjustable steel or plastic package banding.
3. Padding: Burlap.
4. Proprietary Palm-Bracing Devices: Proprietary systems to secure each new planting by trunk; sized according to manufacturer's written recommendations unless otherwise indicated.

## 2.7 TREE-WATERING DEVICES

- A. Watering Pipe: PVC pipe 4 inches (100 mm) in diameter, site-cut to length as required, and with snug-fitting removable cap.
- B. Slow-Release Watering Device: Standard product manufactured for drip irrigation of plants and emptying its water contents over an extended time period; manufactured from UV-light-stabilized nylon-reinforced polyethylene sheet, PVC, or HDPE plastic.
  1. Color: green.

## 2.8 MISCELLANEOUS PRODUCTS

- A. Wood Pressure-Preservative Treatment: AWWA U1, Use Category UC4a; acceptable to authorities having jurisdiction, and containing no arsenic or chromium.
- B. Root Barrier: Black, molded, modular panels 24 inches (610 mm) high (deep), 85 mils (2.2 mm) thick, and with vertical root deflecting ribs protruding 3/4 inch (19 mm) out

from panel surface; manufactured with minimum 50 percent recycled polyethylene plastic with UV inhibitors.

- C. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.
- D. Burlap: Non-synthetic, biodegradable.
- E. Planter Drainage Gravel: Washed, sound crushed stone or gravel complying with ASTM D 448 for Size No. 8.
- F. Planter Filter Fabric: Nonwoven geotextile manufactured for separation applications and made of polypropylene, polyolefin, or polyester fibers or combination of them.
- G. Mycorrhizal Fungi: Dry, granular inoculant containing at least 5300 spores per lb (0.45 kg) of vesicular-arbuscular mycorrhizal fungi and 95 million spores per lb (0.45 kg) of ectomycorrhizal fungi, 33 percent hydrogel, and a maximum of 5.5 percent inert material.

**END OF SECTION 02930**

**SECTION 02945 – PLANTING ACCESSORIES****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Metal edging for straight-line and curvilinear borders along edges of aggregate maintenance strips.

**PART 2 - PRODUCTS****2.1 MATERIALS**

- A. Metal Edging: 1/4 inch, powder coated steel (Col-Met or approved equal).
  - 1. Col-Met, 3333 Miller Park South, Garland TX, telephone: (800) 829-8225, (972) 494-3900, fax (972) 494-1605.
  - 2. Description: "Commercial Grade Steel Landscape Edging" is Hot Rolled low carbon steel ASTM-A-36, ASTM-A-283, ASTM-A-569.
  - 3. Height: (4, 6) inches (10.16, 15.24 cm).
  - 4. Thickness: 1/4 inch (6.35 mm).
  - 5. Length: 10 feet (3.048 meters).
  - 6. Connection Method: Tapered stakes (10Ga. (3.4mm) x 12 inch (30cm)) to match. Section ends shall splice together with an interlocking stakeless snap-down design.
  - 7. Finish: Electrostatically applied powder coating.
  - 8. Color: Black

**2.2 AUXILIARY MATERIALS**

- A. Herbicide: Commercial chemical for weed control, registered by the EPA, and not classified as "restricted use" for locations and conditions of application. Provide in granular, liquid, or wettable powder form.

**END OF SECTION 02945**

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**SECTION 03300 - CAST IN PLACE CONCRETE FOR LANDSCAPE APPLICATIONS****PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section specifies cast-in place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes, for the following:
  - 1. Site work including but not limited to:
    - a. Walkway Paving
- B. Related Sections include the following:
  - 1. Section 07 92 00 – Exterior Joint Sealants

**1.2 DEFINITIONS**

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, subject to approval of mix color.

**1.3 SUBMITTALS**

- A. Product Data: For each type of product indicated.
  - 1. Samples: Submit 1 -48 inch x48 inch samples of each mix design and finish indicating complete range of color, form finish and texture. Rework mix as required at the direction of the Landscape Architect to achieve an acceptable color and finish. Samples may be completed on site or an appropriate offsite location for review by Landscape Architect. If completed off site, samples should be completed such that samples can be moved to the site at Owner/Architects request. Samples shall be reworked and reconstructed as necessary until the required standard of work has been achieved at no cost to the Owner.
  - 2. Design Mixes: Submit design mix for each concrete mix. Submit alternate design mixtures when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments. Include field test data used to establish the required average strength in accordance with ACI 301. Review of design mixes and field test data will be for general information only. Production of concrete to comply with specified requirements is the responsibility of the contractor. Submit written reports to Architect of each proposed mix for each class of concrete at least 15 days prior to start of work. Do not begin concrete production until each mix has been reviewed by the Landscape Architect.
    - a. Indicate amounts of mix water to be withheld for later addition at Project site.
- B. Shop Drawings:
  - 1. Steel Reinforcement Shop Drawings: Submit details of fabrication, bending, and placement, prepared according to ACI 315, "Details and Detailing of Concrete Reinforcement." Include material, grade, bar schedules, stirrup spacing, bent bar diagrams, arrangement, and supports of concrete reinforcement. Include special reinforcement required for openings through concrete structures.
  - 2. Coordinate all dimensions and structural requirement with work by others. This shall include but not be limited to bridge abutments.



- C. Mockups: Construct mockups for each phase of work for demonstration and verification of construction method, dimension, finish and color.
1. Mockups shall be reworked and reconstructed as necessary until the required standard of work has been achieved at no cost to the Owner.
  2. Mockups shall remain in place until completion of the work and shall be demolished afterward unless incorporated into the work at the direction of the Owner and Landscape Architect. Mockups may be completed on site or an appropriate offsite location for review by Landscape Architect. If completed off site, samples should be completed such that samples can be moved to the site at Owner/Architects request.
  3. Approved mockups shall be used as a standard for construction of the same type of material throughout the project. Completed work shall be reviewed in comparison to the mockup. Contractor shall rework mockups until approved by the landscape architect.
  4. The following mockups shall be constructed.
    - a. Construct 100 square foot minimum section that includes each concrete paving type for verification of form of every type of finish, mix quality, color, jointing etc. Approved mockup may be incorporated into the work.

## **PART 2 - PRODUCTS**

### **2.1 STEEL REINFORCEMENT**

- A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.
- B. Epoxy-Coated Reinforcing Bars: ASTM A 775/A 775M.
- C. Plain-Steel Wire: ASTM A 82, as drawn.
- D. Deformed-Steel Wire: ASTM A 496.
- E. Epoxy-Coated Wire: ASTM A 884/A 884M, Class A coated, plain-steel wire.
- F. Plain-Steel Welded Wire Fabric: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.
  1. Welded wire fabric maybe used in lieu of carbon steel fibers for interior slabs on grade and interior elevated concrete topping on metal deck when acceptable to the Architect.
- G. Epoxy-Coated Welded Wire Fabric: ASTM A 884/A 884M, Class A, plain steel.

### **2.2 REINFORCEMENT ACCESSORIES**

- A. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete or fiber-reinforced concrete of greater compressive strength than concrete, and as follows:
  1. For concrete surfaces exposed to view where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected or CRSI Class 2 stainless-steel bar supports.
  2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.

3. For zinc-coated reinforcement, use galvanized wire or dielectric-polymer-coated wire bar supports.
  4. Do not use wood, masonry, concrete or other similar supports.
- B. Joint Dowel Bars: Plain-steel bars, ASTM A 615/A 615M, Grade 60 (Grade 420). Cut bars true to length with ends square and free of burrs.
  - C. Epoxy-Coated Joint Dowel Bars: ASTM A 775/A 775M; with ASTM A 615/A 615M, Grade 60 (Grade 420), plain-steel bars.
  - D. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating; compatible with epoxy coating on reinforcement and complying with ASTM A 775/A 755M.
  - E. Mechanical Reinforcement Couplers: ASTM A-519, Minimum tensile strength 100,000 psi

### 2.3 CONCRETE MATERIALS

- A. Portland Cement: ASTM C 150, Type I. Type III cement may be used in lieu of Type I at Contractor's option, when acceptable to the Landscape Architect.
  1. Use only one brand of cement throughout project, except as otherwise indicated.
- B. Normal-Weight Aggregate: ASTM C 33, uniformly graded, and as follows:
  1. Class: Severe weathering region, but not less than 3S.
  2. Nominal Maximum Aggregate Size: 1/2 inch
  3. Fine graded aggregate be provided. Provide samples for approval.
- C. Lightweight Aggregate: ASTM C 330.
  1. Nominal Maximum Aggregate Size: 3/4 inch (19 mm).
- D. Water: Drinkable and complying with ASTM C 94.

### 2.4 ADMIXTURES

- A. General: Admixtures certified by manufacturer to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material and to be compatible with other admixtures and cementitious materials. Do not use admixtures containing calcium chloride thycyanates or admixtures containing more than 0.1 percent chloride ions.
- B. Air-Entraining Admixture: ASTM C 260.
- C. Water-Reducing Admixture: ASTM C 494, Type A.
- D. High-Range, Water-Reducing Admixture (Super Plasticizer): ASTM C 494, Type F.

### 2.5 WATERSTOPS

- A. Self-Expanding Strip Waterstops: Manufactured rectangular or trapezoidal strip, sodium bentonite or other hydrophylic material for adhesive bonding to concrete.
  1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Volclay Waterstop-RX; Colloid Environmental Technologies Co.
    - b. Conseal CS-231; Concrete Sealants Inc.
    - c. Swellseal Joint; De Neef Construction Chemicals (U.S.) Inc.
    - d. Hydrotite; Greenstreak.
    - e. Mirastop; Mirafi Moisture Protection, Div. of Royal Ten Cate (USA), Inc.
    - f. Adeka Ultra Seal; Mitsubishi International Corporation.
    - g. Superstop; Progress Unlimited Inc.

## 2.6 VAPOR RETARDERS

- A. General Vapor Retarder: ASTM E 1745, Class C, of one of the following materials; or polyethylene sheet, ASTM D 4397, not less than 10 mils (0.25 mm) thick. Use only materials which are resistant to decay when tested in accordance with ASTM E 154:
  - 1. Nonwoven, polyester-reinforced, polyethylene coated sheet; 10 mils (0.25 mm) thick.
  - 2. Three-ply, nylon- or polyester-cord-reinforced, laminated, high-density polyethylene sheet; 7.8 mils (0.18 mm) thick.
- B. Vapor Retarder for Cast-In-Place Concrete at Silva Cell Locations: ASTM E 1745, Class C, of one of the following materials; or polyethylene sheet, ASTM D 4397, not less than 15 mils (0.381 mm) thick. Use only materials which are resistant to decay when tested in accordance with ASTM E 154:
  - 1. Provide Stego Wrap 15 mil. membrane by Stego Industries, LLC prior to placement of concrete at all Silva Cell locations. Tape all seams and seal all penetrations using Stego tape or mastic. Follow manufacturer's instructions for installation.

## 2.7 CURING MATERIALS

- A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) dry.
- B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- C. Water: Drinkable.
- D. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.

## 2.8 RELATED MATERIALS

- A. Joint-Filler Strips: ASTM D 1752, cork or self-expanding cork.
- B. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
- C. Reglets: Fabricate reglets of not less than 26 gage (0.0217-inch) (0.55-mm) thick galvanized steel sheet with 45 degree slot minimum 1" deep and ¼" wide and formed with upper lip bent back to engage concrete. Temporarily fill or cover face opening of reglet to prevent intrusion of concrete or debris.
- D. Dovetail Anchor Slots: Hot-dipped galvanized steel sheet not less than 0.0217 inch (0.55-mm) thick, with bent tab anchors. Temporarily fill or cover face opening of slots to prevent intrusion of concrete or debris.
- E. For on-structure applications see Section 07 33 63 Vegetated Roof Assembly for root barrier, drainage mat and layered foam voiding specifications.

## 2.9 REPAIR MATERIALS

- A. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch (3.2 mm) and that can be feathered at edges to match adjacent floor elevations.

1. Cement Binder: ASTM C 150, Portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
  2. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.
  3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch (3 to 6 mm) or coarse sand as recommended by underlayment manufacturer.
  4. Compressive Strength: Not less than 4100 psi (29 MPa) at 28 days when tested according to ASTM C 109/C 109M.
- B. Repair Topping: Traffic-bearing, cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/4 inch (6 mm).
1. Cement Binder: ASTM C 150, Portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
  2. Primer: Product of topping manufacturer recommended for substrate, conditions, and application.
  3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch (3 to 6 mm) or coarse sand as recommended by topping manufacturer.
  4. Compressive Strength: Not less than 5700 psi (39 MPa) at 28 days when tested according to ASTM C 109/C 109M.

## 2.10 CONCRETE MIXES

- A. Prepare design mixes for each type and strength of concrete determined by either laboratory trial mix or field test data bases, as follows:
- B. Use a qualified independent testing agency for preparing and reporting proposed mix designs for the laboratory trial mix basis.
- C. Provide a minimum 28 day compressive strength of 4000 psi (27.7 MPa) and a maximum water-cementitious material ratio of 0.44, unless otherwise indicated.
- D. Cementitious Materials:
1. For concrete exposed to deicers, limit percentage, by weight, of cementitious materials other than Portland cement according to ACI 301 requirements.
  2. For all other concrete, limit percentage, by weight, of cementitious materials other than Portland cement in concrete as follows:
    - a. Fly Ash: 25 percent by weight, or as required to achieve required color to be determined in mockup approvals process.
    - b. Slag: As required to achieve required color to be determined in mockup approvals process.
- E. Air Content: Use air-entraining admixture in exterior exposed concrete. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having an air content as follows within a tolerance of plus 1 or minus 1.5 percent, unless otherwise indicated:
1. Air Content: 6 percent for 3/4-inch (19-mm) nominal maximum aggregate size.
- F. Admixtures: Use admixtures according to manufacturer's written instructions.
1. Use water-reducing admixture or high-range water-reducing admixture (superplasticizer) in concrete, as required, for placement and workability.
  2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

3. Use water-reducing admixture in pumped concrete, concrete for heavy-use industrial slabs and parking structure slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.
  4. Use corrosion-inhibiting admixture in concrete mixes where indicated.
- G. Prepare design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in ACI 301. If trial batch method is used, use an independent testing facility acceptable to the Architect for preparing and reporting proposed mix designs.
- 2.11 FABRICATING REINFORCEMENT
- A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice." In the case of fabrication errors, do not re-bend or straighten reinforcement.
  - B. Unacceptable Materials: Reinforcement with any of the following defects will not be permitted in the Work:
    1. Bar lengths, depths or bends exceeding specified fabrication tolerances.
    2. Bends or kinks not indicated on the Drawings or final Shop Drawings
    3. Bars with reduced cross section due to excessive corrosion or other cause.
    4. Bars with damaged corrosion resistive coating (if specified).
- 2.12 CONCRETE MIXING
- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94 and ASTM C 1116, and furnish batch ticket information.
    1. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.
- 2.13 CONCRETE FINISHES
- A. Walkways Paving:
    1. Smooth float finish, light "ecoblast" sandblast finish, chamfer profile sawcut joints.
  - B. Ramp Paving:
    1. Smooth float finish, light "ecoblast" sandblast finish, chamfer profile sawcut joints.
- 2.14 SEALERS
- A. For ALL finished Concrete paving and curb surfaces:
    1. Manufactured By: BASF
    2. Contact: 1-800-474-7570
    3. Sealer: Enviroseal 40 Concrete/Masonry Silane Penetrating Sealer
    4. Install per manufacturer's recommendations

**END OF SECTION 03300**

**SECTION 03 33 01 - ARCHITECTURAL CONCRETE FOR LANDSCAPE APPLICATIONS****PART 1 - GENERAL**

## 1.1. DESCRIPTION

- A. Section includes cast-in-place architectural concrete for all finished concrete walls including form facings, reinforcement accessories, concrete materials, concrete mixture design, placement procedures, and finishes.

## 1.2. ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Design Mixtures: For each concrete mixture.
- C. Steel Reinforcement Shop Drawings: Placing drawings that detail fabrication, bending, and placement.
- D. Formwork Shop Drawings: Prepared by or under the supervision of a qualified professional engineer detailing fabrication, assembly, and support of formwork.

## 1.3. INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Material certificates.
- C. Material test reports.

## 1.4. SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Design Mixtures: For each concrete mixture. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

Indicate amounts of mixing water to be withheld for later addition at Project site.

- C. Steel Reinforcement Shop Drawings: Placing drawings that detail fabrication, bending, and placement.
- D. Formwork Shop Drawings: Show formwork construction including form-facing joints, rustications, construction and contraction joints, form joint-sealant details, form tie

locations and patterns, inserts and embedments, cutouts, cleanout panels, release agents and other items that visually affect cast-in-place architectural concrete.

- E. Placement Schedule: Submit concrete placement schedule before start of placement operations. Include locations of all joints including construction joints (bonded or unbonded) and water seal types and locations.
- F. Samples: For each of the following materials:
  - 1. Form-facing panel.
  - 2. Form ties.
  - 3. Form liners.
  - 4. Fine-aggregate gradations.
  - 5. Chamfers and rustications.
- G. Samples for Verification: Architectural concrete Samples, cast vertically, approximately 18 by 18 by 2 inches, of finishes, colors, and textures to match design reference sample. Include Sample sets showing the full range of variations expected in these characteristics.
- H. Material Test Reports: For the following, from a qualified testing agency, indicating compliance with requirements:
  - 1. Aggregates. Include service record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.
- F. Material Certificates: For each of the following, signed by manufacturer:
  - 1. Cementitious materials.
  - 2. Admixtures.
  - 3. Form materials and form-release agents.
  - 4. Repair materials.

#### 1.5. QUALITY ASSURANCE

- A. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.
  - 1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."
  - 2. Source Limitations for Cast-in-Place Architectural Concrete: Obtain each color, size, type, and variety of concrete material and concrete mixture from one manufacturer with resources to provide cast-in-place architectural concrete of consistent quality in appearance and physical properties.
- B. Testing Agency Qualifications: An independent agency, qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.

- C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.4/D 1.4M, "Structural Welding Code - Reinforcing Steel."
- D. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:
1. ACI 301, "Specification for Structural Concrete," Sections 1 through 5 and Section 6, "Architectural Concrete."
  2. ACI 303.1, "Specification for Cast-in-Place Architectural Concrete."
- E. Field Sample Panels: After approval of verification sample and before casting architectural concrete, produce field sample panels to demonstrate the approved range of selections made under sample submittals. Produce a minimum of 3 sets of full-scale panels, cast vertically, approximately 24 inches by 24 inches by 4 inch inches to demonstrate the expected range of finish, color, and texture variations (includes separate panel for black stained concrete).
1. Locate panels as indicated or, if not indicated, as directed by Architect
  2. Demonstrate methods of curing, aggregate exposure, sealers, and coatings, as applicable.
  3. In presence of Architect, damage part of an exposed-face surface for each finish, color, and texture, and demonstrate materials and techniques proposed for repair of tie holes and surface blemishes to match adjacent undamaged surfaces.
  4. Maintain field sample panels during construction in an undisturbed condition as a standard for judging the completed Work.
  5. Demolish and remove field sample panels when directed.
- F. Mockups: Before casting architectural concrete, build mockups to verify selections made under sample submittals and to demonstrate typical joints, surface finish, texture, tolerances, and standard of workmanship. Build mockups to comply with the following requirements, using materials indicated for the completed Work:
1. Build mockups in the location and of the size indicated or, if not indicated, as directed by Landscape Architect.
  2. Build mockups of typical exterior wall of cast-in-place architectural concrete as shown on Drawings. Include mockups of the following:
    - a. Exposed concrete walls. Smooth formed finish with chamfers and vertical and horizontal joints per the Drawings. Mockup to include the entire profile of wall including an end section and full width of an entire panel. Minimum 10' long section to meet above.
    - b. Mockups are not to be incorporated into the final Work.
  3. Demonstrate curing, cleaning, and protecting of cast-in-place architectural concrete, finishes, and contraction joints, as applicable.



4. In presence of Architect, damage part of the exposed-face surface for each finish, color, and texture, and demonstrate materials and techniques proposed for repair of tie holes and surface blemishes to match adjacent undamaged surfaces.
5. Obtain Landscape Architect's approval of mockups before casting architectural concrete. Approved mockups may not become part of the completed Work.

G. Preinstallation Conference: Conduct conference at Project site.

1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place architectural concrete to attend, including the following:
  - a. Contractor's superintendent.
  - b. Independent testing agency responsible for concrete design mixtures.
  - c. Ready-mix concrete manufacturer.
  - d. Cast-in-place architectural concrete subcontractor.
2. Review concrete finishes and finishing, cold- and hot-weather concreting procedures, curing procedures, construction joints, forms and form-removal limitations, reinforcement accessory installation, concrete repair procedures, and protection of cast-in-place architectural concrete.

## **PART 2 – MATERIALS**

### **2.1. FORM-FACING MATERIALS**

- A. Form-Facing Panels for Smooth Form Finishes: Steel, glass-fiber-reinforced plastic, or other approved nonabsorptive panel materials that will provide continuous, true, and smooth architectural concrete surfaces. Furnish in largest practicable sizes to conform to joints per the Drawings.
- B. Form Liners: Units of face design, texture, arrangement, and configuration indicated on drawings. Furnish with manufacturer's recommended liquid-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent surface treatments of concrete.
- C. Chamfer Strips: Metal, rigid plastic, elastomeric rubber, or dressed wood, 3/4 by 3/4 inch, minimum; nonstaining; in longest practicable lengths.
- D. Form Joint Tape: Compressible foam tape; pressure sensitive; AAMA 800, "Specification 810.1, Expanded Cellular Glazing Tape"; minimum 1/4 inch thick.

- E. Form Joint Sealant: Elastomeric sealant complying with ASTM C 920, Type M or S, Grade NS, that adheres to form joint substrates.
- F. Sealer: Penetrating, clear, polyurethane wood form sealer formulated to reduce absorption of bleed water and prevent migration of set-retarding chemicals from wood.
- G. Form-Release Agent: Commercially formulated colorless form-release agent that will not bond with, stain, or adversely affect architectural concrete surfaces and will not impair subsequent treatments of those surfaces.
- H. Formulate form-release agent with rust inhibitor for steel form-facing materials.
- I. Surface Retarder: Chemical liquid set retarder, for application on form-facing materials, capable of temporarily delaying final hardening of newly placed concrete surface to depth of reveal specified.
- J. Form Ties: Factory-fabricated, ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal. Eliminate or conform visible ties to joints per the Drawings.

## 2.2. STEEL REINFORCEMENT AND ACCESSORIES

- A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.
- B. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practice."

## 2.3. CONCRETE MATERIALS

- A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source, throughout Project:
  - 1. Portland Cement: ASTM C 150, Type I,
    - 1. Fly Ash: ASTM C 618, Class F.
    - 2. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
- B. Normal-Weight Aggregates: ASTM C 33, graded.
  - 1. Maximum Coarse-Aggregate Size: 1-1/2 inches nominal.
  - 2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement. Imported fine aggregates shall be used for all polished concrete slabs.

C. Water: ASTM C 94/C 94M and potable.

## 2.4. ADMIXTURES

A. Air-Entraining Admixture: ASTM C 260.

B. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

## 2.5. CURING MATERIALS

A. For concrete indicated to be sealed, curing compound shall be compatible with sealer.

B. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.

C. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. when dry.

D. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

E. Water: Potable.

F. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.

G. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, nondissipating, certified by curing compound manufacturer to not interfere with bonding of floor covering.

H. Clear, Solvent-Borne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.

1. VOC Content: Curing and sealing compounds shall have a VOC content of 200 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - I. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.
    1. VOC Content: Curing and sealing compounds shall have a VOC content of 200 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- 2.6. REPAIR MATERIALS
- A. Bonding Agent: ASTM C 1059, Type II, nonredispersible, acrylic emulsion or styrene butadiene.
  - B. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements.
    1. Types [I and II, non-load bearing] [IV and V, load bearing], for bonding hardened or freshly mixed concrete to hardened concrete.
- 2.7. CONCRETE MIXTURES
- A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.
  - B. Cementitious Materials: Use fly ash, pozzolan, ground granulated blast-furnace slag, and silica fume as needed to reduce the total amount of portland cement, which would otherwise be used, by not more than 25%. Only cement shall be used in polished concrete slabs.
  - C. Admixtures: Use admixtures according to manufacturer's written instructions.
    1. Use water-reducing high-range water-reducing or plasticizing admixture in concrete, as required, for placement and workability.
    2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
    3. Use water-reducing admixture in pumped concrete, concrete for heavy-use industrial slabs and parking structure slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.
  - D. Proportion normal-weight concrete mixture as follows:
    1. Minimum Compressive Strength: 4,000 psi.
    2. Typical Maximum Water-Cementitious Materials Ratio: 0.45.
    3. Air Content: 6 percent, plus or minus 1.5 percent at point of delivery

## 2.8. FABRICATING REINFORCEMENT

1. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

## 2.9. CONCRETE MIXING

- A. Ready-Mixed Architectural Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M and furnish batch ticket information.

1. Clean equipment used to mix and deliver cast-in-place architectural concrete to prevent contamination from other concrete.
2. When air temperature is between 85 and 90 deg F , reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F , reduce mixing and delivery time to 60 minutes.

## 2.10. FORMWORK

- A. Limit deflection of form-facing panels to not exceed ACI 303.1 requirements.
- B. In addition to ACI 303.1 limits on form-facing panel deflection, limit cast-in-place architectural concrete surface irregularities, designated by ACI 347R as abrupt or gradual, as follows:
  1. Class A, 1/8 inch.
  2. Fabricate forms to result in cast-in-place architectural concrete that complies with ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."
  3. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast-in-place surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical. Kerf wood rustications, keyways, reglets, recesses, and the like, for easy removal.
  4. Seal form joints and penetrations at form ties with form joint tape or form joint sealant to prevent cement paste leakage.
  5. Do not use rust-stained steel form-facing material.
- C. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.
- D. Chamfer exterior corners and edges of cast-in-place architectural concrete.
- E. Coat contact surfaces of wood rustications and chamfer strips with sealer before placing reinforcement, anchoring devices, and embedded items.

- F. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.
- G. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.
- H. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
- I. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.
- J. Coat contact surfaces of forms with surface retarder, according to manufacturer's written instructions, before placing reinforcement.
- K. Place form liners accurately to provide finished surface texture indicated. Provide solid backing and attach securely to prevent deflection and maintain stability of liners during concreting. Prevent form liners from sagging and stretching in hot weather. Seal joints of form liners and form liner accessories to prevent mortar leaks. Coat form liner with form-release agent.

#### 2.11. REINFORCEMENT AND INSERTS

- A. Set wire ties with ends directed into concrete at, not toward exposed concrete surfaces.

#### 2.12. REMOVING AND REUSING FORMS

- A. Formwork for sides of beams, walls, columns, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F for 24 hours after placing concrete, if concrete is hard enough to not be damaged by form-removal operations and curing and protection operations are maintained.
- B. Schedule form removal to maintain surface appearance that matches approved mockups.  
Cut off and grind glass-fiber-reinforced plastic form ties flush with surface of concrete.
- C. Leave formwork for beam soffits, joists, slabs, and other structural elements that support weight of concrete in place until concrete has achieved 28-day design compressive strength. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.
- D. Clean and repair surfaces of forms to be reused in the Work. Do not use split, frayed, delaminated, or otherwise damaged form-facing material. Apply new form-release agent.
- E. When forms are reused, clean surfaces, remove fins and laitance, recoat with release agents and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for cast-in-place architectural concrete surfaces.

### 2.13. JOINTS

- A. Construction Joints: Install construction joints true to line with faces perpendicular to surface plane of cast-in-place architectural concrete so strength and appearance of concrete are not impaired, at locations indicated or as approved by Engineer.
1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints, unless otherwise indicated.
  2. Form keyed joints as indicated. Embed keys at least 1-1/2 inches into concrete. Align construction joint within rustications attached to form-facing material.
  3. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
  4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
  5. Space vertical joints in walls as indicated. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
  6. Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
  7. Joints to maintain level tolerance, do not vary from level by more than 1/4 inch in 10 feet, or 1/2 inch maximum.
- B. Contraction Joints: Form weakened-plane contraction joints true to line with faces perpendicular to surface plane of cast-in-place architectural concrete so strength and appearance of concrete are not impaired, at locations indicated or as approved by Engineer.

### 2.14. CONCRETE PLACEMENT

- A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.
- B. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.
1. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.
- C. Cold-Weather Placement: Comply with ACI 306.1.
- D. Hot-Weather Placement: Comply with ACI 301.

## 2.15. FINISHES, GENERAL

- A. Architectural Concrete Finish: Match Architect's design reference sample, identified and described as indicated, to satisfaction of Architect.
- B. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces.
  - 1. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.
- C. Maintain uniformity of special finishes over construction joints, unless otherwise indicated.

## 2.16. AS-CAST FORMED FINISHES

- A. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Remove fins and other projections exceeding specified limits on formed-surface irregularities. Repair and patch tie holes and defects.
- B. Form-Liner Finish: Produce a textured surface free of pockets, streaks, and honeycombs, and of uniform appearance, color, and texture.
- C. Rubbed Finish: Apply the following to smooth-form-finished as-cast concrete where indicated:
  - 1. Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process
  - 2. Grout-Cleaned Finish: Wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix one part portland cement to one and one-half parts fine sand with a 1:1 mixture of bonding admixture and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match surrounding concrete. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.
  - 3. Cork-Floated Finish: Wet concrete surfaces and apply a stiff grout. Mix one part portland cement and one part fine sand with a 1:1 mixture of bonding agent and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match surrounding concrete. Compress grout into voids by grinding surface. In a swirling motion, finish surface with a cork float.

## 2.17. CONCRETE PROTECTING AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and with ACI 301 for hot-weather protection during curing.



- B. Begin curing cast-in-place architectural concrete immediately after removing forms from or applying as-cast formed finishes to concrete. Cure according to ACI 308.1, by one or a combination of the following methods that will not mottle, discolor, or stain concrete:
1. Moisture Curing: Keep exposed surfaces of cast-in-place architectural concrete continuously moist for not less than seven days with the following materials:
    - a. Water.
    - b. Continuous water-fog spray.
    - c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.
  2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period; use cover material and waterproof tape.
  3. Curing Compound: Mist concrete surfaces with water. Apply curing compound uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

## 2.18. REPAIRS, PROTECTION, AND CLEANING

- A. Repair and cure damaged finished surfaces of cast-in-place architectural concrete when approved by Engineer. Match repairs to color, texture, and uniformity of surrounding surfaces and to repairs on approved mockups.
- B. In the event of bug holes in smooth form finish concrete, wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix one part portland cement to one and one-half parts fine sand with a 1:1 mixture of bonding admixture and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match surrounding concrete. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.
- C. Remove and replace cast-in-place architectural concrete that cannot be repaired and cured to Engineer's approval.
- D. Protect corners, edges, and surfaces of cast-in-place architectural concrete from damage; use guards and barricades.
- E. Protect cast-in-place architectural concrete from staining, laitance, and contamination during remainder of construction period.

- F. Clean cast-in-place architectural concrete surfaces after finish treatment to remove stains, markings, dust, and debris.
- G. Wash and rinse surfaces according to concrete finish applicator's written recommendations. Protect other Work from staining or damage due to cleaning operations.
  - 1. Do not use cleaning materials or processes that could change the appearance of cast-in-place architectural concrete finishes.

#### 2.19. WATERPROOFING

- A. Provide Enkadrain B10 drainage mat from grade to footing as shown on Drawings. Ensure all edges are covered to prevent soil integration into drainage mat. Follow manufacturer's instructions to affix to wall.

#### 2.20. FIELD QUALITY CONTROL

- A. Testing and Inspecting: Contractor shall engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

**END OF SECTION 03301**

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**SECTION 05520 – METAL FABRICATIONS – HANDRAILS AND RAILING****PART 1 - GENERAL**

## 1.1. WORK INCLUDES

## A. Base Bid.

## 1. General Contractor Provide:

- a. Metal fabrications work shown on drawings including items fabricated from iron and steel shapes, plates, bars, strips, channels and castings which are not a part of structural steel, or other metal systems in other sections of the project manual. Furnish and install pre-fabricated metal posts, panel fence, rails, gate(s) and hardware as needed.
- b. Work includes but is not limited to the following:
  - 1) Hardware
  - 2) Miscellaneous framing, supports, and anchors
  - 3) Metal Guardrails
- c. Mockup of metal guardrail

## 1.2. QUALITY ASSURANCE

- A. Qualifications of Fabricator: Minimum three years documented experience in successful fabrication of metal work of comparable size and complexity as this project. Submit names, addresses, and telephone numbers of owners, architects, engineers, and project locations.
- B. Field Measurements: Take field measurements prior to preparation of shop drawings and fabrication, where possible. Do not delay job progress; allow for trimming and fitting wherever taking field measurements before fabrication might delay work.
- C. Shop Assembly: Preassemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.
- D. Codes and Standards: Comply with applicable provisions of the following, except as otherwise indicated:
  1. American Institute of Steel Construction (AISC)
  2. ASTM A 6 "Specification for General Requirements for Rolled Steel Plates, Shapes, Sheet Piling, and Bars for Structural Use."
- E. Mockups:

1. Build mockups of metal guardrail consisting of post, top rail, infill picket, and anchorage system components to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication, finishing, and installation. Mockup shall be a minimum of 4 linear feet in length.

## **PART 2 - PRODUCTS**

### **2.1. MATERIALS AND COMPONENTS – METAL**

- A. Metal Surfaces, General: For fabrication of miscellaneous metal work which will be exposed to view, use only materials which are smooth and free of surface blemishes including pitting, seam marks, roller marks, rolled trade names and roughness.
  1. Steel Plates, Shapes and Bars: ASTM A 36.
  2. Brackets, Flanges and Anchors: Cast or formed metal of the same type material and finish as supported rails, unless otherwise indicated.
- B. Fasteners: Use galvanized carbon steel fasteners of the type indicated unless otherwise indicated. Do not use metals that are corrosive or incompatible with metals joined.
- C. Grout and Anchoring Cement:
- D. Non-Shrink Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with CE CRD-C 621. Provide grout specifically recommended by manufacturer for interior and exterior applications of type specified in this section
- E. Erosion-Resistant Anchoring Cement: Factory-prepackaged, nonshrink, nonstaining, hydraulic controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without need for protection by a sealer or waterproof coating and is recommended for exterior use by manufacturer
  1. Products: Subject to compliance with requirements, provide one of the following, or approved equal:
    - a. Nonshrink Nonmetallic Grouts:
      - 1) "Euco- N-S Grout"; Euclid Chemical Co.
      - 2) "Kemset"; Chem-Masters Corp.
      - 3) "SonogROUT"; Sonneborn Building Products Div., Rexnord Chemical Products, Inc.
      - 4) "Materflow 713"; Master Builders.
      - 5) "Sealtight 588 Grout"; W.R. Meadows, Inc..
    - b. Erosion-Resistant Anchoring Cement:

1) "Super Por-Rok"; Minwax Construction Products Division.

- F. Fasteners: Select fasteners for the type, grade, and class required. Provide stainless steel fasteners for exterior use or where built into exterior walls.
1. Bolts and Nuts: Tamper proof head type, ASTM A 307, Grade A.
  2. Lag Bolts: Regular Hexagon head type, FS FF-B-561.
  3. Machine Screws: Cadmium Plated steel, FS FF-S-92
  4. Plain Washers: Round, carbon steel, FS FF-W-92.
  5. Drilled-In Expansion Anchors: Expansion anchors complying with FS FF-S-325, Group VIII (anchors, expansion, [nondrilling], Type I (internally threaded tubular expansion anchor); and machine bolts complying with FS FF-B-575.
  6. Toggle Bolts: Tumble-wing type, FS FF-B-588, type , class, and style as required.
  7. Lock Washers: Helical spring type carbon steel, FS FF-W-84.
  8. Epoxy anchor system: Drilled-in epoxy anchors shall be Hilti HY 150 with type 316 stainless threaded rod, nuts and washers.
- G. Galvanizing: ASTM A123.
1. Tube:  
  
Cold-formed: ASTM A500.  
Galvanizing: In accordance with ASTM A123.
  2. Pipe:  
  
ASTM A53 (black steel and hot-dipped galvanized).  
Galvanizing: ASTM A53, (G185 nominal).

## 2.2. MISCELLANEOUS MATERIALS

- A. Grout: As specified in section 03 30 01.
- B. Concrete: Normal weight ready-mix concrete as specified in Section 03 30 01.
1. Minimum 28-day compressive strength of 4000 pounds per square inch, unless otherwise indicated.
- C. Fasteners: Use fasteners suitable for the material being fastened and for the type of connection required.
1. For exterior use or built into exterior walls: Nonferrous stainless steel, type 316L.
  2. Use fasteners of same material as items being fastened unless otherwise indicated.
  3. Bolts and studs: ASTM A307.
  4. Nuts: ASTM A563.
  5. Lag bolts: FS FF-B-561.
  6. Machine screws: FS FF-S-92.
  7. Plain washers: FS FF-W-92.

8. Lock washers: FS FF-W-84.
  9. Expansion shields: FS FF-S-325.
  10. Toggle bolts: FS FF-B-588.
- D. Sherwin Williams two part polyurethane system: Macropoxy 646 and Hi-solids polyurethane. Contract to use different colors between Macropoxy 646 and Hi-solids to ensure coverage.
- E. Galvanizing Repair Paint: Zinc dust paint complying with SSPC-Paint 20 or DOD P-21035.
- F. Paint:
1. Paint primer: Macropoxy 646 FF Flake Filled Epoxy. Color TBD
  2. Paint: Hi-Solids Polyurethane – Semi-Gloss. Color to be match existing on site
  3. Surface Preparation: After inspection and before shipping, clean steelwork to be painted complying with Steel Structures Painting Council. Remove oil, grease and similar contaminants, complying with SSPC SP-1 "Solvent Cleaning".
  4. Application: Immediately after surface preparation, apply primer paint in accordance with manufacturer's instructions and at a rate to provide a uniform dry film thickness of 1.0 mils. Use painting methods which will result in full coverage of joints, corners, edges and all exposed surfaces.
  5. Landscape Architect to approve final paint selection

**END OF SECTION 05520**

**SECTION 06150 - EXTERIOR CARPENTRY AND MILLWORK****PART 1 - GENERAL**

## 1.1 GENERAL REFERENCE

- A. The work of this Section is integral with the whole of the Contract Documents and is not intended to be interpreted outside that context.

## 1.2 SUMMARY

- A. Section Includes: All labor, materials, equipment and services necessary to complete the work specified on the drawings.
- B. Work includes installation of:
  - 1. Cryo Pond Boardwalk

## 1.3 QUALITY ASSURANCE

- A. FSC Chain of Custody Certified. Provide evidence of certification. Comply with AWI grading standards.
- B. Mock-ups: Construct (1) fence panel; (1) fence post; and pergola panel (size as directed by the Landscape Architect) mock-up of wood assemblies displaying placement of jointing, fasteners and finish. Mockup shall be coordinated with fabricator of structure frame (if applicable).

**PART 2 - PRODUCTS**

## 2.1 LUMBER

- A. Wood Decking for Cryo Pond Boardwalk: Shall be as approved by the Landscape Architect and as shown on the drawings. Boards should be full length per the drawings, clear of all heart, free of heart center, air dried, from old growth, "Architect Clear" grade, S4S E4E, Ipe. Decking to be fastened with concealed fasteners.

## 2.2 FASTENERS

- A. All fasteners grade 316 stainless steel. All fasteners to be concealed.

**END OF SECTION 06150**



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## **SECTION 07900 – EXTERIOR JOINT SEALANTS**

### **PART 1 - GENERAL**

#### 1.1 SUMMARY

- A. This Work shall be performed in accordance with Illinois DOT Standard Specification and as modified herein to include the following:
  - 1. Joint sealants for the applications indicated in the Joint-Sealant Schedule at the end of the section, and as indicated on Drawings.
- B. Related Sections include the following:
  - 1. Section 03 30 01 - Cast In Place Concrete for Landscape Applications

### **PART 2 - PRODUCTS**

#### 2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide one of the products listed below.

#### 2.2 MATERIALS, GENERAL

- A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by sealant manufacturer, based on testing and field experience.
- B. Colors of Exposed Joint Sealants: Refer to Sealant Schedule at the end of this section.

#### 2.3 ELASTOMERIC JOINT SEALANTS

- A. Elastomeric Sealants: Comply with ASTM C 920 and other requirements indicated for each liquid-applied chemically curing sealant specified, including those referencing ASTM C 920 classifications for type, grade, class, and uses related to exposure and joint substrates.
- B. Stain-Test-Response Characteristics: Provide products that have undergone testing according to ASTM C 1248 and have not stained porous joint substrates indicated for Project.
- C. Suitability for Immersion in Liquids. Where elastomeric sealants are indicated for Use I for joints that will be continuously immersed in liquids, provide products that have undergone testing according to ASTM C 1247 and qualify for the length of exposure indicated by reference to ASTM C 920 for Class 1 or 2. Liquid used for testing sealants is deionized water, unless otherwise indicated.

D. Single-Component Low Modulus, Neutral- and Basic-Curing Silicone Sealant:

1. Products:
  - a. Dow Corning Corporation; 790.
  - b. GE Silicones; SilPruf LM SCS2700.
  - c. Tremco; Spectrem 1 (Basic).
  - d. GE Silicones; SilPruf SCS2000.
  - e. Sonneborn, Division of ChemRex Inc.; Omniseal.
2. Type and Grade: S (single component) and NS (nonsag).
3. Class: 100/50.
4. Use Related to Exposure: NT (nontraffic).
5. Uses Related to Joint Substrates: M, G, A, and, as applicable to joint substrates indicated, O.
  - a. Use O Joint Substrates: Coated glass aluminum coated with a high-performance coating brick granite and other Use O substrates.
6. Stain-Test-Response Characteristics: Nonstaining to porous substrates per ASTM C 1248.

E. Single-Component Medium Modulus, Neutral- and Basic-Curing Silicone Sealant:

1. Dow Corning Corporation; 791.
2. Dow Corning Corporation; 795
3. GE Silicones; SilPruf NB SCS9000.
4. GE Silicones; UltraPruf II SCS2900.
5. Type and Grade: S (single component) and NS (nonsag).
6. Class: 50 100/50.
7. Use Related to Exposure: NT (nontraffic).
8. Uses Related to Joint Substrates: M, G, A, and, as applicable to joint substrates indicated, O.
  - a. Use O Joint Substrates: Coated glass aluminum coated with a high-performance coating brick granite and other Use O substrates.
9. Stain-Test-Response Characteristics: Nonstaining to porous substrates per ASTM C 1248.

F. Multicomponent Nonsag Urethane Sealant:

1. Products:
  - a. Sika Corporation, Inc.; Sikaflex - 2c NS TG.
  - b. Sonneborn, Division of ChemRex Inc.; NP 2.
  - c. Tremco; Vulkem 227.
  - d. Tremco; Vulkem 322 DS.
2. Type and Grade: M (multicomponent) and NS (nonsag).
3. Class: 25.

4. Uses Related to Exposure: T (traffic) and NT (nontraffic).
5. Uses Related to Joint Substrates: M, A, and, O as applicable to joint substrates indicated.

G. Single-Component Nonsag Urethane Sealant:

1. Products:
  - a. Sika Corporation, Inc.; Sikaflex - 1a.
  - b. Sonneborn, Division of ChemRex Inc.; NP 1.
  - c. Tremco; Vulkem 116.
2. Type and Grade: S (single component) and NS (nonsag).
3. Class: 25.
4. Uses Related to Exposure: T (traffic) and NT (nontraffic).
5. Uses Related to Joint Substrates: M, A, and O, as applicable to joint substrates indicated.

## 2.4 JOINT-SEALANT BACKING

- A. General: Provide sealant backings of material and type that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.
- B. Cylindrical Sealant Backings: ASTM C 1330, Type B (bicellular material with a surface skin) as approved in writing by joint-sealant manufacturer for joint application indicated, and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance:
  1. Provide one of the following:
    - a. "Sof Rod" by Nomaco
    - b. "Soft Backer Rod" by Sonneborn.
- C. Elastomeric Tubing Sealant Backings: Neoprene, butyl, EPDM, or silicone tubing complying with ASTM D 1056, nonabsorbent to water and gas, and capable of remaining resilient at temperatures down to minus 26 deg F. Provide products with low compression set and of size and shape to provide a secondary seal, to control sealant depth, and to otherwise contribute to optimum sealant performance.
- D. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint where such adhesion would result in sealant failure. Provide self-adhesive tape where applicable.

## 2.5 MISCELLANEOUS MATERIALS

- A. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

- B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.
- C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

### PART 3 - EXECUTION

#### 3.1 SEALANT SCHEDULE

TYPE	POLYMER	EXPOSURE /TRAFFIC	COLOR	USES/APPLICATIONS
Elastomeric	Silicone: Low modulus; Medium Modulus	Exterior joints in vertical surfaces and non-traffic horizontal surfaces	To be Selected by Landscape Architect	<ul style="list-style-type: none"> <li>Control and expansion joints in cast-in-place concrete.</li> <li>Joints in precast concrete.</li> <li>Joints between materials listed above and frames of doors and windows.</li> <li>Other joints as indicated.</li> </ul>
Elastomeric	Two-part Urethane or One-part Urethane	Exterior joints in horizontal traffic surfaces	To be Selected by Landscape Architect	<ul style="list-style-type: none"> <li>Control, expansion, and isolation joints in cast-in-place concrete slabs.</li> <li>Joints in paving.</li> <li>Other joints as indicated.</li> </ul>

**END OF SECTION 07900**

**SECTION 00000 - TABLE OF CONTENTS**

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- 02230 SITE PREPARATION AND TREE PROTECTION
- 02621 SUBDRAINAGE FOR LANDSCAPE APPLICATIONS
- 02910 PLANT PREPARATION
- 02920 LAWN AND GRASSES
- 02930 PLANTING

DIVISION 3 - CONCRETE

- 03301 ARCHITECTURAL CONCRETE FOR LANDSCAPE APPLICATIONS

DIVISION 7 – THERMAL AND MOISTURE PROTECTION

- 07900 EXTERIOR JOINT SEALANTS

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**SECTION 02230 – SITE PREPARATION AND TREE PROTECTION****PART 1 - GENERAL**

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

## 1.2 SUMMARY

- A. Section includes general protection and pruning of existing trees and plants that are affected by execution of the Work, whether temporary or permanent construction.
- B. Related Sections:
  - 1. Division 02 Section "Site Clearing" for removing existing trees and shrubs.

**PART 2 - PRODUCTS**

## 2.1 MATERIALS

- A. Organic Mulch: Free from deleterious materials and suitable as a top dressing for trees and shrubs, consisting of one of the following:
  - 1. Type: Shredded hardwood bark.
  - 2. Size Range: 3 inches maximum, 1/2 inch minimum.
  - 3. Color: Natural.
- B. Protection-Zone Fencing: Fencing fixed in position and meeting the following requirements.
  - 1. Chain-Link Protection-Zone Fencing: Polymer-coated galvanized-steel fencing fabricated from minimum 2-inch opening, 0.148-inch-diameter wire chain-link fabric; with pipe posts, minimum 2-3/8-inch-OD line posts, and 2-7/8-inch-OD corner and pull posts with 0.177-inch-diameter top tension wire] and 0.177-inch-diameter bottom tension wire; with tie wires, hog ring ties, and other accessories for a complete fence system.
    - a. Height: 6 feet.
- C. Protection-Zone Signage: Shop-fabricated, rigid plastic or metal sheet with attachment holes prepunched and reinforced; legibly printed with nonfading lettering and as follows:
  - 1. Size and Text: As shown on Drawings.
  - 2. Lettering: 3-inch-high minimum.

**END OF SECTION – 02230**



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## **SECTION 02621 – SUBDRAINAGE FOR LANDSCAPE APPLICATIONS**

### **PART 1 - GENERAL**

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. The work of this section consists of furnishing and installing subsurface drains in planting and hardscape areas using trench drains, slot drains, perforated drain lines, granular fill material, drainage board, and synthetic filter fabric.

### **PART 2 - PRODUCTS**

#### 2.1 ATRIUM DRAIN IN PLANTING

- A. Model 78 four inch round atrium drain. Color: black. NDS, website: [www.ndspro.com](http://www.ndspro.com) telephone: 888-825-4716.

#### 2.2 FLUSH LANDSCAPE DRAIN IN LAWN

- A. Model 50 six inch round drain. Color: green. NDS, website: [www.ndspro.com](http://www.ndspro.com) telephone: 888-825-4716.

#### 2.3 DRAIN LINES AND PERFORATED DRAIN LINES

- A. Schedule 40 PVC double wall solid pipe. Pipe, manufactured from virgin, low filler cell class PVC resin (12454 per ASTM D1784). Pipe shall be Contech A-2000 as manufactured by Contech construction Products, Inc, Chicago IL Phone 630 573 1110, [www.contech-cpi.com](http://www.contech-cpi.com). All fittings, "T", "Y", end caps, and splices shall be compatible fittings by the same manufacturer. Size - 4" diameter.
- B. Schedule 40 PVC double wall perforated pipe. Pipe, manufactured from virgin, low filler cell class PVC resin (12454 per ASTM D1784). Pipe shall have slots on the bottom quadrant of the pipe of 1-1/16" long by .031" wide at .413 on center. Pipe shall be Contech A-2000 as manufactured by Contech construction Products, Inc, Chicago IL Phone 630 573 1110, [www.contech-cpi.com](http://www.contech-cpi.com). All fittings, "T", "Y", end caps, and splices shall be compatible fittings by the same manufacturer. Size - 4" diameter.

#### 2.4 RISER SLEEVES

- A. Schedule 40 P.V.C. plastic non-perforated pipe size as indicated on the drawings. All caps, "T", "Y", and end caps shall be compatible and made by the same manufacturer.

## 2.5 CLEANOUT

- A. Cast iron clean out ferrule with black ABS plastic plug. Model Joasam #58190. Apply water proof grease on plug threads.

## 2.6 TAPE

- A. Plastic 3" wide, polyethylene tape, 3M #3939.

## 2.7 DRAINAGE AGGREGATE

- A. Coarse aggregate meeting the requirements of AASHTO M 43 Size 57 when tested in accordance with AASHTO T27 omitting AASHTO T11 or washed pea stone gravel.

## 2.8 COARSE SAND

- A. Coarse concrete sand, ASTM C-33 Fine Aggregate, with a Fines Modulus Index of 2.8 and 3.2. Sands shall be clean, sharp, natural sands free of limestone, shale and slate particles.

1. Provide the following particle size distribution:

<u>Sieve</u>	<u>Percent Passing</u>
3/8" (9.5mm)	100
No 4 (4.75mm)	95-100
No 8 (2.36mm)	80-100
No 16(1.18mm)	50-85
No30 (.60mm)	25-60
No50 (.30mm)	10-30
No100 (.15mm)	2-10

## 2.9 DRAINAGE BOARD

- A. Basis of Design: Three-dimensional, non biodegradable plastic material with filter fabric layer. Drainage board is designed to effectively conduct water to the drain outlet. Core thickness 0.4"-1.5" as indicated. Manufactured by BASF Construction Chemicals, LLC – Building Systems, Shakopee, MN, 800-433-9517; LiveRoof, LLC, P.O. Box 533 Spring Lake, MI, phone (800) 875-1392 or approved equal.
- B. Or as recommended by waterproofing manufacturer and approved by landscape architect.

## 2.10 FILTER FABRIC

- A. Woven monofilament geotextile of 100% high-tenacity, monofilament polypropylene yarns with grab strength 255 x 275 lbs., grab elongation 15%, Mullen burst strength 420 psi, percent open area 20%-30%, apparent opening size US standard sieve 20 - 30, water flow rate 200 gpm/sf. Filter fabric shall be delivered in 12 feet wide rolls min. Filter Fabric shall be 'Carthage 30' as manufactured by Carthage Mills, Cincinnati, OH. or approved equal.

**END OF SECTION 02621**

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**SECTION 02910 – PLANT PREPARATION****PART 1 – GENERAL****1.1 SUMMARY**

- A. The scope of work includes all labor, materials, tools, supplies, equipment, facilities, transportation and services necessary for, and incidental to performing all operations in connection with furnishing, delivery, and installation of Planting Soil and /or the modification of existing site soil for use as Planting Soil, complete as shown on the drawings and as specified herein.
- B. The scope of work in this section includes, but is not limited to, the following:
  - 1. Locate, purchase, deliver and install Imported Planting Soil and soil amendments.
  - 2. Harvest and stockpile existing site soils suitable for Planting Soil.
  - 3. Modify existing stockpiled site soil.
    - a. Modify existing site soil in place for use as Planting Soil.
    - b. Install existing or modified existing soil for use as Planting Soil.
  - 4. Locate, purchase, deliver and install subsurface Drain Lines.
  - 5. Fine grade Planting Soil.
  - 6. Install Compost into Planting Soils.
  - 7. Clean up and disposal of all excess and surplus material.

**END OF SECTION 02910**

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**SECTION 02920 – LAWNS AND GRASSES****PART 1 - GENERAL**

## 1.1 RELATED DOCUMENTS

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

## 1.2 SUMMARY

- A. Section Includes:
  - 1. Sodding.

**PART 2 - PRODUCTS**

## 2.1 TURFGRASS SOD

- A. Turfgrass Sod: Certified, Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture that is strongly rooted and capable of vigorous growth and development when planted.
- B. Turfgrass Species: Sod of grass species as follows, with not less than 85 percent germination, not less than 95 percent pure seed, and not more than 0.5 percent weed seed:
  - 1. Full Sun: Kentucky bluegrass (*Poa pratensis*), a minimum of three cultivars.
  - 2. Sun and Partial Shade: Proportioned by weight as follows:
    - a. 50 percent Kentucky bluegrass (*Poa pratensis*).
    - b. 30 percent chewings red fescue (*Festuca rubra* variety).
    - c. 10 percent perennial ryegrass (*Lolium perenne*).
    - d. 10 percent redbot (*Agrostis alba*).
  - 3. Shade: Proportioned by weight as follows:
    - a. 50 percent chewings red fescue (*Festuca rubra* variety).
    - b. 35 percent rough bluegrass (*Poa trivialis*).
    - c. 15 percent redbot (*Agrostis alba*).

**END OF SECTION 02920**



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## **SECTION 02930 - PLANTING**

### **PART 1 - GENERAL**

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:
  - 1. Plants.
  - 2. Tree stabilization.
  - 3. Tree-watering devices.

### **PART 2 - PRODUCTS**

#### 2.1 PLANT MATERIAL

- A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
  - 1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch (19 mm) in diameter; or with stem girdling roots are unacceptable.
  - 2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
- B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Landscape Architect, with a proportionate increase in size of roots or balls.
- C. Plants shall have outstanding form; symmetrical, heavily-branched with an even branch distribution, densely foliated and/or budded, and a strong, straight distinct leader where this is characteristic of the species. Plants shall possess a normal balance for the

species between height and spread. The Landscape Architect shall be the final arbiter of acceptability of plant form.

- D. Provide healthy, vigorous stock, grown in a recognized nursery in accordance with good horticultural practice and free of disease, insects, eggs, larvae, and defects such as knots, scrapes, broken or split branches, fresh limb cuts, sunscald, injuries, abrasions, or disfigurement. All graft unions shall be completely healed, free of extreme succulence.
- E. All trees and shrubs shall be dug prior to leafing out (bud break) in the spring or when plants have gone dormant in the fall except for the following species, which are only to be dug prior to leafing out in the Spring:
1. Alnus species
  2. Betula species
  3. Carpinus species
  4. Celtis species
  5. Cercidiphyllum species
  6. Cornus species
  7. Crataegus species
  8. Fagus species
  9. Halesia species
  10. Ilex opaca species
  11. Koelreuteria paniculata
  12. Larix species
  13. Liquidambar species
  14. Liriodendron species
  15. Malus – in leaf
  16. Nyssa sylvatica
  17. Ostrya virginiana
  18. Populus species
  19. Prunus – all stone fruits
  20. Pyrus species
  21. Quercus—all oaks except Q. palustris
  22. Salix – weeping varieties
  23. Syringa reticulata
  24. Taxodium distichum
  25. Tilia tomentosa varieties
  26. Ulmus species
  27. Viburnum lentago
  28. Zelkova species

Where project schedule does not permit digging at the appropriate time the contractor shall be responsible for sourcing above-ground material. Above-ground material shall be subject to the same standards for quality and warranty.

- F. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

- G. Labeling: Label each plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant.
- H. If formal arrangements or consecutive order of plants is indicated on Drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.
- I. Annuals and Biennials: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery and that are in bud but not yet in bloom.

## 2.2 FERTILIZERS AND MYCORRHIZA

- A. Planting Soil Supplements (For All Trees, Shrubs, Perennials, Groundcovers, Vines and Annual Bedding Plants):
  - 1. Product: Assure 5-5-5 with Mycorrhiza or approved equivalent.
  - 2. Application Rate: By application type per Manufacturer.
  - 3. Contact: [www.assurefertilize.com](http://www.assurefertilize.com).
- B. Planting Tablets: Tightly compressed chip-type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.
  - 1. Size: 21-gram tablets.
  - 2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

## 2.3 MULCHES

- A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:
  - 1. Type: A blend of 50% Shredded Hardwood Bark Fines and 50% Pine Bark Fines.
  - 2. Size Range:  $\frac{3}{4}$ " for both Shredded Hardwood Bark Fines and Pine Bark Fines.
  - 3. Color: Natural.
  - 4. Installation Depth:
    - a. Tree and Shrubs: 3 inches
    - b. Ornamental Grasses: 2 inches
    - c. Perennials: 2 inches
    - d. Groundcover: 2 Inches
- B. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through a 1-inch (25-

mm) sieve; soluble-salt content of 2 to 5 dS/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

1. Organic Matter Content: 50 to 60 percent of dry weight.
2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

## 2.4 WEED-CONTROL BARRIERS

- A. Nonwoven Geotextile Filter Fabric: Polypropylene or polyester fabric, 3 oz./sq. yd. (101g/sq. m) minimum, composed of fibers formed into a stable network so that fibers retain their relative position. Fabric shall be inert to biological degradation and resist naturally encountered chemicals, alkalis, and acids.
- B. Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, 4.8 oz./sq. yd. (162 g/sq. m).

## 2.5 PESTICIDES

- A. General: Pesticide registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
- B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
- C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

## 2.6 TREE-STABILIZATION MATERIALS

- A. Trunk-Stabilization Materials:
  1. Upright and Guy Stakes: Rough-sawn, sound, new hardwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal (38-by-38-mm actual) by length indicated, pointed at one end.
  2. Wood Deadmen: Timbers measuring 8 inches (200 mm) in diameter and 48 inches (1200 mm) long, treated with specified wood pressure-preservative treatment.
  3. Flexible Ties: Wide rubber or elastic bands or straps of length required to reach stakes or compression springs.
  4. Guys and Tie Wires: ASTM A 641/A 641M, Class 1, galvanized-steel wire, two-strand, twisted, 0.106 inch (2.7 mm) in diameter.
  5. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.

6. Guy Cables: Five-strand, 3/16-inch- (4.8-mm-) diameter, galvanized-steel cable, with zinc-coated turnbuckles, a minimum of 3 inches (75 mm) long, with two 3/8-inch (10-mm) galvanized eyebolts.
7. Flags: Standard surveyor's plastic flagging tape, white, 6 inches (150 mm) long.
8. Proprietary Staking-and-Guying Devices: Proprietary stake or anchor and adjustable tie systems to secure each new planting by plant stem; sized as indicated and according to manufacturer's written recommendations.

B. Root-Ball Stabilization Materials:

1. Upright Stakes and Horizontal Hold-Down: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal (38-by-38-mm actual) by length indicated; stakes pointed at one end.
2. Wood Screws: ASME B18.6.1.
3. Proprietary Root-Ball Stabilization Devices: Proprietary at- or below-grade stabilization systems to secure each new planting by root ball and that do not encircle the trunk; sized according to manufacturer's written recommendations unless otherwise indicated.

C. Palm Bracing: Battens or blocks, struts, straps, and protective padding.

1. Battens or Blocks and Struts: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, 2-by-4-inch nominal (38-by-89-mm actual) by lengths indicated.
2. Straps: Adjustable steel or plastic package banding.
3. Padding: Burlap.
4. Proprietary Palm-Bracing Devices: Proprietary systems to secure each new planting by trunk; sized according to manufacturer's written recommendations unless otherwise indicated.

## 2.7 TREE-WATERING DEVICES

- A. Watering Pipe: PVC pipe 4 inches (100 mm) in diameter, site-cut to length as required, and with snug-fitting removable cap.
- B. Slow-Release Watering Device: Standard product manufactured for drip irrigation of plants and emptying its water contents over an extended time period; manufactured from UV-light-stabilized nylon-reinforced polyethylene sheet, PVC, or HDPE plastic.
  1. Color: green.

## 2.8 MISCELLANEOUS PRODUCTS

- A. Wood Pressure-Preservative Treatment: AWWA U1, Use Category UC4a; acceptable to authorities having jurisdiction, and containing no arsenic or chromium.
- B. Root Barrier: Black, molded, modular panels 24 inches (610 mm) high (deep), 85 mils (2.2 mm) thick, and with vertical root deflecting ribs protruding 3/4 inch (19 mm) out

from panel surface; manufactured with minimum 50 percent recycled polyethylene plastic with UV inhibitors.

- C. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.
- D. Burlap: Non-synthetic, biodegradable.
- E. Planter Drainage Gravel: Washed, sound crushed stone or gravel complying with ASTM D 448 for Size No. 8.
- F. Planter Filter Fabric: Nonwoven geotextile manufactured for separation applications and made of polypropylene, polyolefin, or polyester fibers or combination of them.
- G. Mycorrhizal Fungi: Dry, granular inoculant containing at least 5300 spores per lb (0.45 kg) of vesicular-arbuscular mycorrhizal fungi and 95 million spores per lb (0.45 kg) of ectomycorrhizal fungi, 33 percent hydrogel, and a maximum of 5.5 percent inert material.

**END OF SECTION 02930**

**SECTION 03 33 01 - ARCHITECTURAL CONCRETE FOR LANDSCAPE APPLICATIONS****PART 1 - GENERAL**

## 1.1. DESCRIPTION

- A. Section includes cast-in-place architectural concrete for all finished concrete walls including form facings, reinforcement accessories, concrete materials, concrete mixture design, placement procedures, and finishes.

## 1.2. ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Design Mixtures: For each concrete mixture.
- C. Steel Reinforcement Shop Drawings: Placing drawings that detail fabrication, bending, and placement.
- D. Formwork Shop Drawings: Prepared by or under the supervision of a qualified professional engineer detailing fabrication, assembly, and support of formwork.

## 1.3. INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Material certificates.
- C. Material test reports.

## 1.4. SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Design Mixtures: For each concrete mixture. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

Indicate amounts of mixing water to be withheld for later addition at Project site.

- C. Steel Reinforcement Shop Drawings: Placing drawings that detail fabrication, bending, and placement.
- D. Formwork Shop Drawings: Show formwork construction including form-facing joints, rustications, construction and contraction joints, form joint-sealant details, form tie



locations and patterns, inserts and embedments, cutouts, cleanout panels, release agents and other items that visually affect cast-in-place architectural concrete.

- E. Placement Schedule: Submit concrete placement schedule before start of placement operations. Include locations of all joints including construction joints (bonded or unbonded) and water seal types and locations.
- F. Samples: For each of the following materials:
  - 1. Form-facing panel.
  - 2. Form ties.
  - 3. Form liners.
  - 4. Fine-aggregate gradations.
  - 5. Chamfers and rustications.
- G. Samples for Verification: Architectural concrete Samples, cast vertically, approximately 18 by 18 by 2 inches, of finishes, colors, and textures to match design reference sample. Include Sample sets showing the full range of variations expected in these characteristics.
- H. Material Test Reports: For the following, from a qualified testing agency, indicating compliance with requirements:
  - 1. Aggregates. Include service record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.
- F. Material Certificates: For each of the following, signed by manufacturer:
  - 1. Cementitious materials.
  - 2. Admixtures.
  - 3. Form materials and form-release agents.
  - 4. Repair materials.

#### 1.5. QUALITY ASSURANCE

- A. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.
  - 1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."
  - 2. Source Limitations for Cast-in-Place Architectural Concrete: Obtain each color, size, type, and variety of concrete material and concrete mixture from one manufacturer with resources to provide cast-in-place architectural concrete of consistent quality in appearance and physical properties.
- B. Testing Agency Qualifications: An independent agency, qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.

- C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.4/D 1.4M, "Structural Welding Code - Reinforcing Steel."
- D. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:
1. ACI 301, "Specification for Structural Concrete," Sections 1 through 5 and Section 6, "Architectural Concrete."
  2. ACI 303.1, "Specification for Cast-in-Place Architectural Concrete."
- E. Field Sample Panels: After approval of verification sample and before casting architectural concrete, produce field sample panels to demonstrate the approved range of selections made under sample submittals. Produce a minimum of 3 sets of full-scale panels, cast vertically, approximately 24 inches by 24 inches by 4 inch inches to demonstrate the expected range of finish, color, and texture variations (includes separate panel for black stained concrete).
1. Locate panels as indicated or, if not indicated, as directed by Architect
  2. Demonstrate methods of curing, aggregate exposure, sealers, and coatings, as applicable.
  3. In presence of Architect, damage part of an exposed-face surface for each finish, color, and texture, and demonstrate materials and techniques proposed for repair of tie holes and surface blemishes to match adjacent undamaged surfaces.
  4. Maintain field sample panels during construction in an undisturbed condition as a standard for judging the completed Work.
  5. Demolish and remove field sample panels when directed.
- F. Mockups: Before casting architectural concrete, build mockups to verify selections made under sample submittals and to demonstrate typical joints, surface finish, texture, tolerances, and standard of workmanship. Build mockups to comply with the following requirements, using materials indicated for the completed Work:
1. Build mockups in the location and of the size indicated or, if not indicated, as directed by Landscape Architect.
  2. Build mockups of typical exterior wall of cast-in-place architectural concrete as shown on Drawings. Include mockups of the following:
    - a. Exposed concrete walls. Smooth formed finish with chamfers and vertical and horizontal joints per the Drawings. Mockup to include the entire profile of wall including an end section and full width of an entire panel. Minimum 10' long section to meet above.
    - b. Mockups are not to be incorporated into the final Work.
  3. Demonstrate curing, cleaning, and protecting of cast-in-place architectural concrete, finishes, and contraction joints, as applicable.

4. In presence of Architect, damage part of the exposed-face surface for each finish, color, and texture, and demonstrate materials and techniques proposed for repair of tie holes and surface blemishes to match adjacent undamaged surfaces.
5. Obtain Landscape Architect's approval of mockups before casting architectural concrete. Approved mockups may not become part of the completed Work.

G. Preinstallation Conference: Conduct conference at Project site.

1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place architectural concrete to attend, including the following:
  - a. Contractor's superintendent.
  - b. Independent testing agency responsible for concrete design mixtures.
  - c. Ready-mix concrete manufacturer.
  - d. Cast-in-place architectural concrete subcontractor.
2. Review concrete finishes and finishing, cold- and hot-weather concreting procedures, curing procedures, construction joints, forms and form-removal limitations, reinforcement accessory installation, concrete repair procedures, and protection of cast-in-place architectural concrete.

## **PART 2 – MATERIALS**

### **2.1. FORM-FACING MATERIALS**

- A. Form-Facing Panels for Smooth Form Finishes: Steel, glass-fiber-reinforced plastic, or other approved nonabsorptive panel materials that will provide continuous, true, and smooth architectural concrete surfaces. Furnish in largest practicable sizes to conform to joints per the Drawings.
- B. Form Liners: Units of face design, texture, arrangement, and configuration indicated on drawings. Furnish with manufacturer's recommended liquid-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent surface treatments of concrete.
- C. Chamfer Strips: Metal, rigid plastic, elastomeric rubber, or dressed wood, 3/4 by 3/4 inch, minimum; nonstaining; in longest practicable lengths.
- D. Form Joint Tape: Compressible foam tape; pressure sensitive; AAMA 800, "Specification 810.1, Expanded Cellular Glazing Tape"; minimum 1/4 inch thick.

- E. Form Joint Sealant: Elastomeric sealant complying with ASTM C 920, Type M or S, Grade NS, that adheres to form joint substrates.
- F. Sealer: Penetrating, clear, polyurethane wood form sealer formulated to reduce absorption of bleed water and prevent migration of set-retarding chemicals from wood.
- G. Form-Release Agent: Commercially formulated colorless form-release agent that will not bond with, stain, or adversely affect architectural concrete surfaces and will not impair subsequent treatments of those surfaces.
- H. Formulate form-release agent with rust inhibitor for steel form-facing materials.
- I. Surface Retarder: Chemical liquid set retarder, for application on form-facing materials, capable of temporarily delaying final hardening of newly placed concrete surface to depth of reveal specified.
- J. Form Ties: Factory-fabricated, ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal. Eliminate or conform visible ties to joints per the Drawings.

## 2.2. STEEL REINFORCEMENT AND ACCESSORIES

- A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.
- B. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practice."

## 2.3. CONCRETE MATERIALS

- A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source, throughout Project:
  - 1. Portland Cement: ASTM C 150, Type I,
    - 1. Fly Ash: ASTM C 618, Class F.
    - 2. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
- B. Normal-Weight Aggregates: ASTM C 33, graded.
  - 1. Maximum Coarse-Aggregate Size: 1-1/2 inches nominal.
  - 2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement. Imported fine aggregates shall be used for all polished concrete slabs.

C. Water: ASTM C 94/C 94M and potable.

## 2.4. ADMIXTURES

A. Air-Entraining Admixture: ASTM C 260.

B. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

## 2.5. CURING MATERIALS

A. For concrete indicated to be sealed, curing compound shall be compatible with sealer.

B. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.

C. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. when dry.

D. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

E. Water: Potable.

F. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.

G. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, nondissipating, certified by curing compound manufacturer to not interfere with bonding of floor covering.

H. Clear, Solvent-Borne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.

1. VOC Content: Curing and sealing compounds shall have a VOC content of 200 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - I. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A.
    1. VOC Content: Curing and sealing compounds shall have a VOC content of 200 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- 2.6. REPAIR MATERIALS
- A. Bonding Agent: ASTM C 1059, Type II, nonredispersible, acrylic emulsion or styrene butadiene.
  - B. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements.
    1. Types [I and II, non-load bearing] [IV and V, load bearing], for bonding hardened or freshly mixed concrete to hardened concrete.
- 2.7. CONCRETE MIXTURES
- A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.
  - B. Cementitious Materials: Use fly ash, pozzolan, ground granulated blast-furnace slag, and silica fume as needed to reduce the total amount of portland cement, which would otherwise be used, by not more than 25%. Only cement shall be used in polished concrete slabs.
  - C. Admixtures: Use admixtures according to manufacturer's written instructions.
    1. Use water-reducing high-range water-reducing or plasticizing admixture in concrete, as required, for placement and workability.
    2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
    3. Use water-reducing admixture in pumped concrete, concrete for heavy-use industrial slabs and parking structure slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.
  - D. Proportion normal-weight concrete mixture as follows:
    1. Minimum Compressive Strength: 4,000 psi.
    2. Typical Maximum Water-Cementitious Materials Ratio: 0.45.
    3. Air Content: 6 percent, plus or minus 1.5 percent at point of delivery

## 2.8. FABRICATING REINFORCEMENT

1. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

## 2.9. CONCRETE MIXING

- A. Ready-Mixed Architectural Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M and furnish batch ticket information.

1. Clean equipment used to mix and deliver cast-in-place architectural concrete to prevent contamination from other concrete.
2. When air temperature is between 85 and 90 deg F , reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F , reduce mixing and delivery time to 60 minutes.

## 2.10. FORMWORK

- A. Limit deflection of form-facing panels to not exceed ACI 303.1 requirements.
- B. In addition to ACI 303.1 limits on form-facing panel deflection, limit cast-in-place architectural concrete surface irregularities, designated by ACI 347R as abrupt or gradual, as follows:
  1. Class A, 1/8 inch.
  2. Fabricate forms to result in cast-in-place architectural concrete that complies with ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."
  3. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast-in-place surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical. Kerf wood rustications, keyways, reglets, recesses, and the like, for easy removal.
  4. Seal form joints and penetrations at form ties with form joint tape or form joint sealant to prevent cement paste leakage.
  5. Do not use rust-stained steel form-facing material.
- C. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.
- D. Chamfer exterior corners and edges of cast-in-place architectural concrete.
- E. Coat contact surfaces of wood rustications and chamfer strips with sealer before placing reinforcement, anchoring devices, and embedded items.

- F. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.
- G. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.
- H. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
- I. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.
- J. Coat contact surfaces of forms with surface retarder, according to manufacturer's written instructions, before placing reinforcement.
- K. Place form liners accurately to provide finished surface texture indicated. Provide solid backing and attach securely to prevent deflection and maintain stability of liners during concreting. Prevent form liners from sagging and stretching in hot weather. Seal joints of form liners and form liner accessories to prevent mortar leaks. Coat form liner with form-release agent.

#### 2.11. REINFORCEMENT AND INSERTS

- A. Set wire ties with ends directed into concrete at, not toward exposed concrete surfaces.

#### 2.12. REMOVING AND REUSING FORMS

- A. Formwork for sides of beams, walls, columns, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F for 24 hours after placing concrete, if concrete is hard enough to not be damaged by form-removal operations and curing and protection operations are maintained.
- B. Schedule form removal to maintain surface appearance that matches approved mockups.  
Cut off and grind glass-fiber-reinforced plastic form ties flush with surface of concrete.
- C. Leave formwork for beam soffits, joists, slabs, and other structural elements that support weight of concrete in place until concrete has achieved 28-day design compressive strength. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.
- D. Clean and repair surfaces of forms to be reused in the Work. Do not use split, frayed, delaminated, or otherwise damaged form-facing material. Apply new form-release agent.
- E. When forms are reused, clean surfaces, remove fins and laitance, recoat with release agents and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for cast-in-place architectural concrete surfaces.



## 2.13. JOINTS

- A. Construction Joints: Install construction joints true to line with faces perpendicular to surface plane of cast-in-place architectural concrete so strength and appearance of concrete are not impaired, at locations indicated or as approved by Engineer.
1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints, unless otherwise indicated.
  2. Form keyed joints as indicated. Embed keys at least 1-1/2 inches into concrete. Align construction joint within rustications attached to form-facing material.
  3. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
  4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
  5. Space vertical joints in walls as indicated. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
  6. Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
  7. Joints to maintain level tolerance, do not vary from level by more than 1/4 inch in 10 feet, or 1/2 inch maximum.
- B. Contraction Joints: Form weakened-plane contraction joints true to line with faces perpendicular to surface plane of cast-in-place architectural concrete so strength and appearance of concrete are not impaired, at locations indicated or as approved by Engineer.

## 2.14. CONCRETE PLACEMENT

- A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.
- B. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.
1. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.
- C. Cold-Weather Placement: Comply with ACI 306.1.
- D. Hot-Weather Placement: Comply with ACI 301.

## 2.15. FINISHES, GENERAL

- A. Architectural Concrete Finish: Match Architect's design reference sample, identified and described as indicated, to satisfaction of Architect.
- B. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces.
  - 1. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.
- C. Maintain uniformity of special finishes over construction joints, unless otherwise indicated.

## 2.16. AS-CAST FORMED FINISHES

- A. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Remove fins and other projections exceeding specified limits on formed-surface irregularities. Repair and patch tie holes and defects.
- B. Form-Liner Finish: Produce a textured surface free of pockets, streaks, and honeycombs, and of uniform appearance, color, and texture.
- C. Rubbed Finish: Apply the following to smooth-form-finished as-cast concrete where indicated:
  - 1. Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process
  - 2. Grout-Cleaned Finish: Wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix one part portland cement to one and one-half parts fine sand with a 1:1 mixture of bonding admixture and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match surrounding concrete. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.
  - 3. Cork-Floated Finish: Wet concrete surfaces and apply a stiff grout. Mix one part portland cement and one part fine sand with a 1:1 mixture of bonding agent and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match surrounding concrete. Compress grout into voids by grinding surface. In a swirling motion, finish surface with a cork float.

## 2.17. CONCRETE PROTECTING AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and with ACI 301 for hot-weather protection during curing.

- B. Begin curing cast-in-place architectural concrete immediately after removing forms from or applying as-cast formed finishes to concrete. Cure according to ACI 308.1, by one or a combination of the following methods that will not mottle, discolor, or stain concrete:
1. Moisture Curing: Keep exposed surfaces of cast-in-place architectural concrete continuously moist for not less than seven days with the following materials:
    - a. Water.
    - b. Continuous water-fog spray.
    - c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.
  2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period; use cover material and waterproof tape.
  3. Curing Compound: Mist concrete surfaces with water. Apply curing compound uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

## 2.18. REPAIRS, PROTECTION, AND CLEANING

- A. Repair and cure damaged finished surfaces of cast-in-place architectural concrete when approved by Engineer. Match repairs to color, texture, and uniformity of surrounding surfaces and to repairs on approved mockups.
- B. In the event of bug holes in smooth form finish concrete, wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix one part portland cement to one and one-half parts fine sand with a 1:1 mixture of bonding admixture and water. Add white portland cement in amounts determined by trial patches so color of dry grout will match surrounding concrete. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.
- C. Remove and replace cast-in-place architectural concrete that cannot be repaired and cured to Engineer's approval.
- D. Protect corners, edges, and surfaces of cast-in-place architectural concrete from damage; use guards and barricades.
- E. Protect cast-in-place architectural concrete from staining, laitance, and contamination during remainder of construction period.

- F. Clean cast-in-place architectural concrete surfaces after finish treatment to remove stains, markings, dust, and debris.
- G. Wash and rinse surfaces according to concrete finish applicator's written recommendations. Protect other Work from staining or damage due to cleaning operations.
  - 1. Do not use cleaning materials or processes that could change the appearance of cast-in-place architectural concrete finishes.

#### 2.19. WATERPROOFING

- A. Provide Enkadrain B10 drainage mat from grade to footing as shown on Drawings. Ensure all edges are covered to prevent soil integration into drainage mat. Follow manufacturer's instructions to affix to wall.

#### 2.20. FIELD QUALITY CONTROL

- A. Testing and Inspecting: Contractor shall engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

**END OF SECTION 03301**

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## **SECTION 07900 – EXTERIOR JOINT SEALANTS**

### **PART 1 - GENERAL**

#### 1.1 SUMMARY

- A. This Work shall be performed in accordance with Illinois DOT Standard Specification and as modified herein to include the following:
  - 1. Joint sealants for the applications indicated in the Joint-Sealant Schedule at the end of the section, and as indicated on Drawings.
- B. Related Sections include the following:
  - 1. Section 03 30 01 - Cast In Place Concrete for Landscape Applications

### **PART 2 - PRODUCTS**

#### 2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide one of the products listed below.

#### 2.2 MATERIALS, GENERAL

- A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by sealant manufacturer, based on testing and field experience.
- B. Colors of Exposed Joint Sealants: Refer to Sealant Schedule at the end of this section.

#### 2.3 ELASTOMERIC JOINT SEALANTS

- A. Elastomeric Sealants: Comply with ASTM C 920 and other requirements indicated for each liquid-applied chemically curing sealant specified, including those referencing ASTM C 920 classifications for type, grade, class, and uses related to exposure and joint substrates.
- B. Stain-Test-Response Characteristics: Provide products that have undergone testing according to ASTM C 1248 and have not stained porous joint substrates indicated for Project.
- C. Suitability for Immersion in Liquids. Where elastomeric sealants are indicated for Use I for joints that will be continuously immersed in liquids, provide products that have undergone testing according to ASTM C 1247 and qualify for the length of exposure indicated by reference to ASTM C 920 for Class 1 or 2. Liquid used for testing sealants is deionized water, unless otherwise indicated.

D. Single-Component Low Modulus, Neutral- and Basic-Curing Silicone Sealant:

1. Products:
  - a. Dow Corning Corporation; 790.
  - b. GE Silicones; SilPruf LM SCS2700.
  - c. Tremco; Spectrem 1 (Basic).
  - d. GE Silicones; SilPruf SCS2000.
  - e. Sonneborn, Division of ChemRex Inc.; Omniseal.
2. Type and Grade: S (single component) and NS (nonsag).
3. Class: 100/50.
4. Use Related to Exposure: NT (nontraffic).
5. Uses Related to Joint Substrates: M, G, A, and, as applicable to joint substrates indicated, O.
  - a. Use O Joint Substrates: Coated glass aluminum coated with a high-performance coating brick granite and other Use O substrates.
6. Stain-Test-Response Characteristics: Nonstaining to porous substrates per ASTM C 1248.

E. Single-Component Medium Modulus, Neutral- and Basic-Curing Silicone Sealant:

1. Dow Corning Corporation; 791.
2. Dow Corning Corporation; 795
3. GE Silicones; SilPruf NB SCS9000.
4. GE Silicones; UltraPruf II SCS2900.
5. Type and Grade: S (single component) and NS (nonsag).
6. Class: 50 100/50.
7. Use Related to Exposure: NT (nontraffic).
8. Uses Related to Joint Substrates: M, G, A, and, as applicable to joint substrates indicated, O.
  - a. Use O Joint Substrates: Coated glass aluminum coated with a high-performance coating brick granite and other Use O substrates.
9. Stain-Test-Response Characteristics: Nonstaining to porous substrates per ASTM C 1248.

F. Multicomponent Nonsag Urethane Sealant:

1. Products:
  - a. Sika Corporation, Inc.; Sikaflex - 2c NS TG.
  - b. Sonneborn, Division of ChemRex Inc.; NP 2.
  - c. Tremco; Vulkem 227.
  - d. Tremco; Vulkem 322 DS.
2. Type and Grade: M (multicomponent) and NS (nonsag).
3. Class: 25.

4. Uses Related to Exposure: T (traffic) and NT (nontraffic).
5. Uses Related to Joint Substrates: M, A, and, O as applicable to joint substrates indicated.

G. Single-Component Nonsag Urethane Sealant:

1. Products:
  - a. Sika Corporation, Inc.; Sikaflex - 1a.
  - b. Sonneborn, Division of ChemRex Inc.; NP 1.
  - c. Tremco; Vulkem 116.
2. Type and Grade: S (single component) and NS (nonsag).
3. Class: 25.
4. Uses Related to Exposure: T (traffic) and NT (nontraffic).
5. Uses Related to Joint Substrates: M, A, and O, as applicable to joint substrates indicated.

## 2.4 JOINT-SEALANT BACKING

- A. General: Provide sealant backings of material and type that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.
- B. Cylindrical Sealant Backings: ASTM C 1330, Type B (bicellular material with a surface skin) as approved in writing by joint-sealant manufacturer for joint application indicated, and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance:
  1. Provide one of the following:
    - a. "Sof Rod" by Nomaco
    - b. "Soft Backer Rod" by Sonneborn.
- C. Elastomeric Tubing Sealant Backings: Neoprene, butyl, EPDM, or silicone tubing complying with ASTM D 1056, nonabsorbent to water and gas, and capable of remaining resilient at temperatures down to minus 26 deg F. Provide products with low compression set and of size and shape to provide a secondary seal, to control sealant depth, and to otherwise contribute to optimum sealant performance.
- D. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint where such adhesion would result in sealant failure. Provide self-adhesive tape where applicable.

## 2.5 MISCELLANEOUS MATERIALS

- A. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.



- B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.
- C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

**PART 3 - EXECUTION**

**3.1 SEALANT SCHEDULE**

TYPE	POLYMER	EXPOSURE /TRAFFIC	COLOR	USES/APPLICATIONS
Elastomeric	Silicone: Low modulus; Medium Modulus	Exterior joints in vertical surfaces and non-traffic horizontal surfaces	To be Selected by Landscape Architect	<ul style="list-style-type: none"> <li>• Control and expansion joints in cast-in-place concrete.</li> <li>• Joints in precast concrete.</li> <li>• Joints between materials listed above and frames of doors and windows.</li> <li>• Other joints as indicated.</li> </ul>
Elastomeric	Two-part Urethane or One-part Urethane	Exterior joints in horizontal traffic surfaces	To be Selected by Landscape Architect	<ul style="list-style-type: none"> <li>• Control, expansion, and isolation joints in cast-in-place concrete slabs.</li> <li>• Joints in paving.</li> <li>• Other joints as indicated.</li> </ul>

**END OF SECTION 07900**

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## **SECTION 16010 - BASIC ELECTRICAL REQUIREMENTS**

### **PART 1 - GENERAL**

#### **1.1 SECTION INCLUDES**

- A. Requirements applicable to all Division 16 Sections. Also refer to Division 1 - General Requirements.
- B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced in each specification section.

#### **1.2 SCOPE OF WORK**

- A. This Specification and the associated drawings govern furnishing, installing, testing and placing into satisfactory operation the Electrical Systems.
- B. The Subcontractor shall furnish and install all new materials as indicated on the drawings, and/or in these specifications, and all items required to make his portion of the Electrical Work a finished and working system.
- C. Description of Systems shall be as follows:
  - 1. Medium voltage system including duct bank, pads, cable, manholes and air switches.

#### **1.3 QUALITY ASSURANCE**

- A. Qualifications:
  - 1. Only products of reputable manufacturers as determined by Fermilab are acceptable.
  - 2. All Subcontractors and Subcontractors shall employ only workmen who are skilled in their trades. At all times, the number of apprentices at the job site shall be less than or equal to the number of journeymen at the job site.
- B. Examination of Drawings:
  - 1. The drawings for the electrical work are completely diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment, outlets, etc., and the approximate sizes of equipment.
  - 2. Subcontractor shall determine the exact locations of equipment and rough-ins, and the exact routing of raceways so as to best fit the layout of the job. Conduit entry points for electrical equipment including, but not limited to, panelboards, switchboards, switchgear and unit substations, shall be

determined by the Subcontractor unless noted in the contract documents.

3. Scaling of the drawings will not be sufficient or accurate for determining these locations.
4. Where job conditions require reasonable changes in arrangements and locations, such changes shall be made by the Subcontractor at no additional cost to Fermilab.
5. Because of the scale of the drawings, certain basic items, such as junction boxes, pull boxes, conduit fittings, etc., may not be shown, but where required by other sections of the specifications or required for proper installation of the work, such items shall be furnished and installed.
6. If an item is either shown on the drawings or called for in the specifications, it shall be included in this contract.
7. The Subcontractor shall determine quantities and quality of material and equipment required from the documents. Where discrepancies arise between drawings, schedules and/or specifications, the greater and better quality number shall govern.
8. Where used in electrical documents the word "furnish" shall mean supply for use, the word "install" shall mean connect up complete and ready for operation, and the word "provide" shall mean to supply for use and connect up complete and ready for operation.
9. Any item listed as furnished shall also be installed unless otherwise noted.
10. Any item listed as installed shall also be furnished unless otherwise noted.

C. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.
2. Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.
3. If the information requested includes floor plans prepared by others, the Subcontractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.
4. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.
5. The drawings prepared for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.

6. The use of these CAD documents by the Subcontractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.

D. Field Measurements:

1. Verify all pertinent dimensions at the job site before ordering any conduit, conductors, wireways, bus duct, fittings, etc.

#### 1.4 SUBMITTALS

- A. Refer to Division 1 for submittal requirements.

#### 1.5 PRODUCT DELIVERY, STORAGE, HANDLING AND MAINTENANCE

- A. Exercise care in transporting and handling to avoid damage to materials. Store materials on the site to prevent damage.
- B. Keep all materials clean, dry and free from damaging environments.
- C. Coordinate the installation of heavy and large equipment with the General Subcontractor and/or Fermilab. If the Electrical Subcontractor does not have prior documented experience in rigging and lifting similar equipment, he/she shall contract with a qualified lifting and rigging service that has similar documented experience. Follow all equipment lifting and support guidelines for handling and moving.
- D. Subcontractor is responsible for moving equipment into the building and/or site. Subcontractor shall review site prior to bid for path locations and any required building modifications to allow movement of equipment. Subcontractor shall coordinate his/her work with other trades.

### **PART 2 - PRODUCTS**

#### 2.1 GENERAL

- A. All items of material having a similar function shall be of the same manufacturer unless specifically stated otherwise on drawings or elsewhere in specifications.

### **PART 3 - EXECUTION**

#### 3.1 EXCAVATION, FILL, BACKFILL, COMPACTION

A. General:

1. The Subcontractor shall do all excavating, filling, backfilling, compacting, and restoration in connection with his work. Contact Fermilab prior to commencement of any excavation or digging.

**B. Excavation:**

1. Make all excavations to accurate, solid, undisturbed earth, and to proper dimensions.
2. If excavations are carried in error below indicated levels, concrete of same strength as specified for the foundations or thoroughly compacted sand-gravel fill, as determined by Fermilab shall be placed in such excess excavations under the foundation. Place thoroughly compacted, clean, stable fill in excess excavations under slabs on grade, at the Subcontractor's expense.
3. Trim bottom and sides of excavations to grades required for foundations.
4. Protect excavations against frost and freezing.
5. Take care in excavating not to damage surrounding structures, equipment or buried pipe. Do not undermine footing or foundation.
6. Perform all trenching in a manner to prevent cave-ins and risk to workmen.
7. Where original surface is pavement or concrete, the surface shall be saw cut to provide clean edges and assist in the surface restoration.
8. If satisfactory bearing soil is not found at the indicated levels, immediately notify Fermilab or their representative, and do no further work until Fermilab or their representative gives further instructions.
9. Excavation shall be performed in all ground conditions, including rock, if encountered. Bidders shall visit the premises and determine the soil conditions by actual observations, borings, or other means. The cost of all such inspections, borings, etc., shall be borne by the bidder.
10. If a trench is excavated in rock, a compacted bed with a depth of 3" (minimum) of sand and gravel shall be used to support the conduit unless masonry cradles or encasements are used.
11. Mechanical excavation of the trench to line and grade of the conduit or to the bottom level of masonry cradles or encasements is permitted, unless otherwise indicated on the electrical drawings.
12. Mechanical excavation of the trench to line and grade where direct burial cables are to be installed is permitted provided the excavation is made to a depth to permit installation of the cable on a fine sand bed at least 3 inches deep.

**C. Dewatering:**

1. Furnish, install, operate and remove all dewatering pumps and pipes needed to keep trenches and pits free of water.

D. Underground Obstructions:

1. Known underground piping, conduit, feeders, foundations, and other obstructions in the vicinity of construction are shown on the drawings. Review all Bid Documents for all trades on the project to determine obstructions indicated. Take great care in making installations near underground obstructions.
2. If objects not shown on the drawings are encountered, remove, relocate, or perform extra work as directed by Fermilab.

E. Fill and Backfilling:

1. No rubbish or waste material is permitted for fill or backfill.
2. Furnish all necessary sand for backfilling.
3. Dispose of the excess excavated earth as directed.
4. Backfill materials shall be suitable for required compaction, clean and free of perishable materials, frozen earth, debris, earth with a high void content, and stones greater than 4 inches in diameter. Water is not permitted to rise in unbackfilled trenches.
5. Backfill all trenches and excavations immediately after installing of conduit, or removing forms, unless other protection is directed.
6. Around piers and isolated foundations and structures, backfill and fill shall be placed and consolidated simultaneously on all sides to prevent wedge action and displacement. Spread fill and backfill materials in 6" uniform horizontal layers with each layer compacted separately to required density.
7. For conduits that are not concrete encased, lay all conduits on a compacted bed of sand at least 3" deep. Backfill around conduits with sand, in 6" layers and compact each layer.
8. Conduits that are concrete encased or in a ductbank, conduit spacers, and cradles shall be installed on a bed of compacted CA-6 gravel. Refer to conduit section for backfilling and ductbank requirements.
9. Backfill with sand up to grade for all conduits under slabs or paved areas. All other conduits shall have sand backfill to 6" above the top of the conduit.
10. Place all backfill above the sand in uniform layers not exceeding 6" deep. Place then carefully and uniformly tamp each layer to eliminate lateral or vertical displacement.
11. Where the fill and backfill will ultimately be under a building, floor or paving, each layer of fill shall be compacted to 95% of the maximum density as determined by AASHTO Designation T-99 or ASTM Designation D-698. Moisture content of soil at time of compaction shall not exceed plus or

minus 2% of optimum moisture content as determined by AASHTO T-99 or ASTM D-698 test.

12. After backfilling of trenches, no superficial loads shall be placed on the exposed surface of the backfill until a period of 48 hours has elapsed.

F. Surface Restoration:

1. Where trenches are cut through graded, planted or landscaped areas, the areas shall be restored to the original condition. Replace all planting and landscaping features removed or damaged to its original condition. At least 6" of topsoil shall be applied where disturbed areas are to be seeded or sodded. All lawn areas shall be sodded unless seeding is called out in the drawings or specifications.
2. Concrete or asphalt type pavement, seal coat, rock, gravel or earth surfaces removed or damaged shall be replaced with comparable materials and restored to original condition. Broken edges shall be saw cut and repaired as directed by Fermilab.

### 3.2 PROJECT CLOSEOUT

- A. The following paragraphs supplement the requirements of Division 1.
- B. The following must be submitted before Fermilab recommends final payment:
  1. Operation and maintenance manuals with copies of approved shop drawings.
  2. Record documents including reproducible drawings and specifications.
  3. A report documenting the instructions given to Fermilab's representatives complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of this Subcontractor and shall be signed by Fermilab's representatives.
  4. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to project site and place in location as directed and submit receipt to Fermilab.
  5. Inspection and testing report by the fire alarm system manufacturer.
  6. Start-up reports on all equipment requiring a factory installation or start-up.

### 3.3 OPERATION AND MAINTENANCE MANUALS

A. General:

1. Provide an electronic copy of the O&M manuals as described below for review and approval. The electronic copy shall be corrected as required to address comments. Once corrected, electronic copies and paper copies shall be distributed as directed.



2. Approved O&M manuals shall be completed and in Fermilab's possession prior to Fermilab's acceptance and at least 10 days prior to instruction of operating personnel.

B. Electronic Submittal Procedures:

1. Distribution: Submit the O&M manual.
2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.
3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.
  - a. O&M file name: O&M.div23.Subcontractor.YYYYMMDD
  - b. Transmittal file name: O&Mtransmittal.div23.Subcontractor.YYYYMMDD
5. File Size: Electronic file size shall be limited to a maximum of 4MB. Larger files shall be divided into files that are clearly labeled as "1 of 2", "2 of 2", etc.
6. Provide Fermilab with an approved copy of the O&M manual on compact discs (CD), digital video discs (DVD), or flash drives with a permanently affixed label, printed with the title "Operation and Maintenance Instructions", title of the project and subject matter of disc/flash drive when multiple disc/flash drives are required.
7. Bookmarks shall be used, dividing information first by specification section, then systems, major equipment and finally individual items. All bookmark titles shall include the nomenclature used in the construction documents and shall be an active link to the first page of the section being referenced.

C. Operation and Maintenance Instructions shall include:

1. Title Page: Include title page with project title, Architect, Engineer, all Subcontractors, and major equipment suppliers, with addresses, telephone numbers, website addresses, email addresses and point of contacts. Website URLs and email addresses shall be active links in the electronic submittal.
2. Table of Contents: Include a table of contents describing specification section, systems, major equipment, and individual items.

3. Copies of all final approved shop drawings and submittals. Include Fermilab's shop drawing review comments. Insert the individual shop drawing directly after the Operation and Maintenance information for the item(s) in the review form.
4. Copies of all factory inspections and/or equipment startup reports.
5. Copies of warranties.
6. Schematic wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.
7. Dimensional drawings of equipment.
8. Detailed parts lists with lists of suppliers.
9. Operating procedures for each system.
10. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.
11. Repair procedures for major components.
12. Replacement parts and service material requirements for each system and the frequency of service required.
13. Instruction books, cards, and manuals furnished with the equipment.
14. Include record drawings of the one-line diagrams for each major system. The graphic for each piece of equipment shown on the one-line diagram shall be an active link to its associated Operation & Maintenance data.

### 3.4 INSTRUCTING THE FERMILAB REPRESENTATIVE

- A. Adequately instruct the Fermilab designated representatives in the maintenance, care, and operation of the complete systems installed under this contract.

### 3.5 RECORD DOCUMENTS

- A. The following paragraphs supplement the requirements of Division 1.
- B. Maintain at the job site a separate and complete set of electrical drawings and specifications with all changes made to the systems clearly and permanently marked in complete detail.
- C. Mark drawings and specifications to indicate approved substitutions; Change Orders, and actual equipment and materials used. All Change Orders, RFI responses, Clarifications and other supplemental instructions shall be marked on the documents. Record documents that merely reference the existence of the above items are not acceptable.

- D. Record changes daily and keep the marked drawings available for Fermilab's examination at any normal work time.
- E. Upon completing the job, and before final payment is made, give the marked-up drawings to Fermilab.

### 3.6 ADJUST AND CLEAN

- A. Thoroughly clean all equipment and systems prior to Fermilab's final acceptance of the project.
- B. Clean all foreign paint, grease, oil, dirt, labels, stickers, etc. from all equipment.
- C. Remove all rubbish, debris, etc., accumulated during construction from the premises.

### 3.7 SPECIAL REQUIREMENTS

- A. Coordinate the installation of all equipment, controls, devices, etc., with other trades to maintain clear access area for servicing.
- B. Install all equipment to maximize access to parts needing service or maintenance. Review the final location, placement, and orientation of equipment with Fermilab's representative prior to setting equipment.
- C. Installation of equipment or devices without regard to coordination of access requirements and confirmation with Fermilab's representative will result in removal and reinstallation of the equipment at the Subcontractor's expense.

### 3.8 SYSTEM COMMISSIONING

- A. The electrical systems shall be complete and operating. System start-up, testing, balancing, and satisfactory system performance is the responsibility of the Subcontractor. This includes all calibration and adjustment of electrical controls, balancing of loads, troubleshooting and verification of software, and final adjustments that may be needed.
- B. All operating conditions and control sequences shall be tested during the start-up period. Testing all interlocks, safety shut-downs, controls, and alarms.
  - 1. The Subcontractor and equipment suppliers shall have skilled technicians to ensure that all systems perform properly. If Fermilab is requested to visit the job site for trouble shooting, assisting in start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period, through no fault of the design; the Subcontractor shall reimburse Fermilab on a time and materials basis for services rendered at Fermilab's standard hourly rates in effect when the services are requested. The Subcontractor shall pay Fermilab for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

### 3.9 FIELD QUALITY CONTROL

#### A. General:

1. Conduct all tests required during and after construction.
2. Supply necessary instruments, meters, etc., for the tests. Supply competent technicians with training in the proper testing techniques.
3. All cables and wires shall be tested for shorts and grounds following installation and connection to devices. Replace shorted or grounded wires and cables.
4. Any wiring device, electrical apparatus or lighting fixture, if grounded or shorted on any integral "live" part, shall have all defective parts or materials replaced.

#### B. Ground Resistance:

1. Conduct service ground resistance tests using an approved manufactured ground resistance meter. Submit to Fermilab a proposed test procedure including type of equipment to be used. (The conventional ohmmeter is not an acceptable device.)
2. Make ground resistance measurements during normal dry weather and not less than 48 hours after a rain. Ground resistance values shall be verified by Fermi Lab at the time the readings are taken.
3. If the ground resistance value obtained is more than the value set forth in Section 16450, the following shall be done to obtain the value given:
  - a. Verify that all connections in the service ground system are secure.
  - b. Increase the depth to which ground rods are driven by adding section lengths to the rods and retest. If the resistance is still excessive increase the depth by adding an additional rod section and retest.
  - c. If the resistance is still excessive, furnish and install additional ground rods, spaced not less than 20 feet from other ground rods unless otherwise noted on plans, and connect into the ground electrode system. Retest.
  - d. Review results with Fermilab.
4. Before final payment is made to the Subcontractor submit a written report to Fermilab including the following:
  - a. Date of test.
  - b. Number of hours since the last rain.

- c. Soil condition at the time of the test in the ground electrode location. That is: dry, wet, moist, sand, clay, etc.
  - d. Diagram of the test set-up showing distances between test equipment, ground electrode, auxiliary electrodes, etc.
  - e. Make, model, and calibration date of test equipment.
  - f. Tabulation of measurements taken and calculations made.
- C. Other Equipment:
- 1. Give other equipment furnished and installed by the Subcontractor all standard tests normally made to assure that the equipment is electrically sound, all connections properly made, phase rotation correct, fuses and thermal elements suitable for protection against overloads, voltage complies with equipment nameplate rating, and full load amperes are within equipment rating.
- D. If any test results are not satisfactory, make adjustments, replacements and changes as needed and repeat the tests and make additional tests as Fermilab or authority having jurisdiction deem necessary.

**END OF SECTION 16010**

**SECTION 16100 - DUCTBANK****PART 1 - GENERAL**

- 1.1 SCOPE OF WORK: Work of this section includes ductbank, concrete encasement, reinforcing, trenching and backfilling, and handholes. Subcontractor shall furnish, install, terminate, test and place into operation all material, as specified herein and as shown on the subcontract drawings.
- 1.2 RELATED WORK: The following sections include items of related work. Coordinate work prescribed by this section with work prescribed by these sections.
- A. Section 02220 – Excavating for Structures, Utilities and Pavements.
  - B. Section 02221 – Backfilling and Compacting for Structures, Utilities and Pavements.
  - C. Section 03300 – Cast-in-Place Concrete.
- 1.3 APPLICABLE STANDARDS: The publications listed below form part of this section. Each publication shall be the latest revision and addendum in effect on the date of the subcontract award, unless noted otherwise. Except as specifically modified by the requirements specified herein or the details on the drawings, the work included under this section shall conform to the provisions of these publications.
- A. ANSI (American National Standards Institute):
    - 1. Standard C80.1.
    - 2. Standard C80.3.
    - 3. Standard C2 (National Electrical Safety Code).
  - B. ASTM (American Society for Testing Materials):
    - 1. Standard A615.
  - C. NEMA (National Electrical Manufacturers Association):
    - 1. Standard RN1.
    - 2. Standard TC-2.
    - 3. Standard TC-3.
  - D. NFPA (National Fire Protection Association):
    - 1. NFPA 70 (National Electrical Code).
  - E. UL: (Underwriters' Laboratories, Inc.):

1. UL 651.
  2. UL 6.
- F. Federal Specifications WW-C-540c.
- G. Federal Specifications WW-C-581d.
- 1.4 DELIVERY, STORAGE AND HANDLING: Reinforcing steel and conduit supports shall be stored on pallets, covered to protect them from weather.
- 1.5 SUBMITTALS: Submittal documentation shall be in accordance with Exhibit A, Section 12.
- A. The following submittal documents shall be furnished prior to equipment installation:
1. Conduit (Type and size).
  2. Conduit Supports.
  3. Handholes.
- 1.6 QUALITY ASSURANCE AND CONTROL
- A. Subcontractor shall be responsible for quality control and construction inspection in accordance with Exhibit A.
- B. All work is subject to the final acceptance by Fermilab. Strict conformance to the drawings and specifications shall be required.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL**

- A. All electrical materials shall be new, undamaged and installed for the purpose as manufactured.
- B. Substitutions for material as called for on the drawings will be permitted only upon receipt of written approval by the Fermilab Construction Coordinator.
- C. All electrical materials shall be UL listed.
- D. All conduits shall be encased in 2,000 psi concrete. Red colored dye shall be added to the top of the concrete.
- E. Concrete Encased Type EB PVC: Concrete encased Type EB PVC conduit shall be installed for all below grade ductbank. All below grade conduit under paved surfaces receiving vehicular traffic shall be reinforced concrete encased Type EB PVC. All other exterior below grade conduit shall be concrete encased Schedule 40 PVC, unless otherwise noted.

## 2.2 CONDUIT AND DUCT

- A. Rigid Plastic Conduit: Refer to Specification 16111.
- B. Fittings: PVC conduit fittings, NEMA TC-3.

2.3 ACCESSORIES: Fittings and conduit supports shall be suitable for use with conduits and ducts supplied. Rigid PVC spacers selected to provide minimum duct spacings and concrete cover depths indicated, while supporting ducts during installation. Underground Devices Inc.

2.4 HANDHOLES: Handholes shall be constructed of polymer concrete reinforced with fiberglass, rated for heavy vehicular traffic. Covers shall be of same material as box, colored gray, labeled for "Electrical" or "Telecommunications" and secured with stainless steel penta-head bolts. Boxes shall be gasketed water tight construction. Quazite (Strongwell), Associated Plastics, Inc.

## PART 3 - EXECUTION

### 3.1 DUCTBANK

#### A. Excavation for Ductbank:

1. The ground shall be excavated in open trenches to width, depth and in direction necessary for proper installation of underground ductwork and any handholes, etc., and connections as may be shown on plans.
2. Any necessary sheathing to prevent cave-ins, etc. shall be provided by this Subcontractor.
3. Where muck or unstable ground is encountered in bottom of trench, it shall be excavated to a depth of at least 12 in. below line of duct or slab. Where bottom of trench is excavated below necessary elevation, it shall be brought to proper grade by use of torpedo sand or 3/8 in. gravel, well compacted.
4. Where excavation for its entire depth is in water or wet sand, Subcontractor shall install a pumping system connected with well points so as to drain same effectively.
5. Excavations shall be deeper than minimum wherever required in order that ducts or conduits may be installed so as to avoid new or existing piping, etc., as directed by Fermilab Construction Coordinator.
6. Should conduits, ducts, etc. pass under sidewalks, roads, or curbs, Subcontractor shall take up same in order to install conduit or ducts. All sidewalks, roads or curbs shall be replaced with material equal to that removed and shall be as approved by Fermilab Construction Coordinator.



7. SUBCONTRACTOR SHALL PROCEED WITH CAUTION IN EXCAVATION AND PREPARATION OF TRENCH SO THAT EXACT LOCATION OF UNDERGROUND STRUCTURES, UTILITIES AND PIPING, BOTH KNOWN AND UNKNOWN, MAY BE DETERMINED, AND SUBCONTRACTOR SHALL BE HELD RESPONSIBLE FOR REPAIR OF SUCH STRUCTURES, UTILITIES AND PIPING WHEN BROKEN OR OTHERWISE DAMAGED BY SUBCONTRACTOR.

B. Installation of Ductbank:

1. All underground ductbank shall be a minimum of 2 ft - 6 in. below finished grade to top of top duct in bank or as detailed in plans and/or specifications.
2. Extend concrete encasement for ductbank to all handholes, unless otherwise indicated on the drawings, enter and exit all handholes and foundation walls utilizing PVC conduit with end bells.
3. All duct runs shall be separated and supported (before backfilling or pouring concrete) on precast concrete or performed PVC spacers. Minimum space between conduits shall be 2 in. or as detailed on plans.
4. Materials for concrete shall be thoroughly mixed and immediately placed in trench around rigid conduits and ducts. No concrete that has been allowed to partially set shall be used. After duct runs are completed and concrete is set, Subcontractor shall backfill trenches and tamp thoroughly so as to settle the fill.
5. Before Subcontractor pulls any cables into ducts he shall have a mandrel 1/4 in. smaller than duct inside diameter and approximately 20 in. long pulled through each duct, and if any concrete or obstructions are found, Subcontractor shall remove them and clear ducts.

C. Concreting and Forms: All concreting and form work necessary in connection with construction and concreting around plastic and metal duct runs underground shall be provided by this Subcontractor.

D. Removal of Water: Subcontractor shall at all times during construction provide and maintain ample means and devices with which to promptly remove and properly dispose of all water entering excavations or other parts of work and shall keep said excavations dry until all work to be performed therein has been completed.

**END OF SECTION 16100**

## **SECTION 16111 - CONDUIT AND BOXES**

### **PART 1 - GENERAL**

#### **1.1 SECTION INCLUDES**

- A. Rigid metallic conduit and fittings
- B. Rigid polyvinyl chloride conduit and fittings

#### **1.2 REFERENCES**

- A. American National Standards Institute (ANSI):
  - 1. ANSI C80.1 - Rigid Steel Conduit, Zinc-Coated
  - 2. ANSI C80.4 - Fittings for Rigid Metal Conduit and Electrical Metallic Tubing
  - 3. ANSI/NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports
- B. NECA "Standards of Installation"
- C. National Electrical Manufacturers Association (NEMA):
  - 1. RN 1 – Polyvinyl chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
  - 2. TC 2 – Electrical Polyvinyl Chloride (PVC) Conduit
  - 3. TC 9 – Fittings for PVC Plastic Utilities Duct for Underground Installation
- D. National Fire Protection Association (NFPA):
  - 1. ANSI/NFPA 70 – National Electrical Code
- E. Definitions:
  - 1. Fittings: Conduit connection or coupling.
  - 2. Body: Enlarged fittings with opening allowing access to the conductors for pulling purposes only.
  - 3. Mechanical Spaces: Enclosed areas, usually kept separated from the general public, where the primary use is to house service equipment and to route services. These spaces generally have exposed structures, bare concrete and non-architecturally emphasized finishes.
  - 4. Finished Spaces: Enclosed areas where the primary use is to house personnel and the general public. These spaces generally have architecturally emphasized finishes, ceilings and/or floors.

5. Concealed: Not visible by the general public. Often indicates a location either above the ceiling, in the walls, in or beneath the floor slab, in column coverings, or in the ceiling construction.
6. Above Grade: Not directly in contact with the earth. For example, an interior wall located at an elevation below the finished grade shall be considered above grade but a wall retaining earth shall be considered below grade.
7. Slab: Horizontal pour of concrete used for the purpose of a floor or sub-floor.

### 1.3 SUBMITTALS

- A. Provide product submittals to Fermilab, per specifications.

## PART 2 - PRODUCTS

### 2.1 RIGID METALLIC CONDUIT (RMC) AND FITTINGS

- A. Acceptable Manufacturers:
  1. Acceptable Manufacturers: Allied, LTV, Steelduct, Wheatland Tube Co, O-Z Gedney, or approved equal.
  2. Acceptable Manufacturers of RMC Conduit Fittings: Appleton Electric, O-Z/Gedney Co., Electroline, Raco, Bridgeport, Midwest, Regal, Thomas & Betts, Crouse-Hinds, Killark, or approved equal.
- B. Fittings and Conduit Bodies:
  1. End Bell Fittings: Malleable iron, hot dip galvanized, threaded flare type with provisions for mounting to form.
  2. Expansion Joints: Malleable iron and hot dip galvanized providing a minimum of 4 inches of movement. Fitting shall be watertight with an insulating bushing and a bonding jumper.
  3. Expansion Joint for Concrete Encased Conduit: Neoprene sleeve with bronze end coupling, stainless steel bands and tinned copper braid bonding jumper. Fittings shall be watertight and concrete-tight.
  4. Conduit End Bushings: Malleable iron type with molded-on high impact phenolic thermosetting insulation. Where required elsewhere in the contract documents, bushing shall be complete with ground conductor saddle and clamp. High impact phenolic threaded type bushings are not acceptable.
  5. All other fittings and conduit bodies shall be of malleable iron construction and hot dip galvanized.

## 2.2 RIGID NON-METALLIC CONDUIT (PVC) AND FITTINGS

- A. Minimum Size Rigid Smooth-Wall Nonmetallic Conduit: 3/4 inch, unless otherwise noted.
- B. Acceptable Manufacturers: Carlon (Lamson & Sessions) Type 40, Cantex, J.M. Mfg., or approved equal.
- C. Construction: Schedule 40 and Schedule 80 rigid polyvinyl chloride (PVC), UL labeled for 90°C.
- D. Fittings and Conduit Bodies: NEMA TC 3; sleeve type suitable for and manufactured especially for use with the conduit by the conduit manufacturer.
- E. Plastic cement for joining conduit and fittings shall be provided as recommended by the manufacturer.

## PART 3 - EXECUTION

### 3.1 CONDUIT SIZING

- A. Size conduit as shown on the drawings and specifications. Where not indicated in the contract documents, conduit size shall be according to N.E.C. (Latest Edition). Conduit and conductor sizing shall be coordinated to limit conductor fill to less than 40%, maintain conductor ampere capacity as required by the National Electrical Code (to include enlarged conductors due to temperature and quantity derating values) and to prevent excessive voltage drop and pulling tension due to long conduit/conductor lengths.

### 3.2 CONDUIT ARRANGEMENT

- A. Subcontractor shall cooperate with all Subcontractors on the project. He shall obtain details of other Subcontractor's work in order to ensure fit and avoid conflict. Any expense due to the failure of This Subcontractor to do so shall be paid for in full by him. The other trades involved as directed by Fermilab shall perform the repair of work damaged as a result of neglect or error by This Subcontractor. The resultant costs shall be borne by This Subcontractor.

### 3.3 CONDUIT INSTALLATION

- A. Conduit Connections:
  - 1. Shorter than standard conduit lengths shall be cut square using industry standards. The ends of all conduits cut shall be reamed or otherwise finished to remove all rough edges.
  - 2. Install expansion/deflection joints where conduit crosses structure expansion/seismic joints.
- B. Conduit terminations for all low voltage wiring shall have nylon bushings installed on each end of every conduit run.

**C. Conduit Bends:**

1. Use a hydraulic one-shot conduit bender or factory elbows for bends in conduit 2" in size or larger. All steel conduit bending shall be done cold; no heating of steel conduit shall be permitted.
2. All bends of rigid polyvinyl chloride conduit (PVC) shall be made with the manufacturer's approved bending equipment. The use of spot heating devices will not be permitted (i.e. blow torches).
3. A run of conduit shall not contain more than the equivalent of four (4) quarter bends (360°), including those bends located immediately at the outlet or body.
4. Rigid polyvinyl chloride conduit (PVC) runs longer than 100 feet or runs which have more than two 90° equivalent bends (regardless of length) shall use rigid metal or RTRC factory elbows for bends.
5. Use conduit bodies to make sharp changes in direction (i.e. around beams).

**D. Conduit Placement:**

1. Conduit shall be mechanically continuous from source of current to all outlets. Conduit shall be electrically continuous from source of current to all outlets, unless a properly sized grounding conductor is routed within the conduit. All metallic conduits shall be bonded per the National Electrical Code.
2. Avoid moisture traps where possible. Where unavoidable, provide a junction box with drain fitting at conduit low point.
3. SUBCONTRACTOR SHALL BE RESPONSIBLE FOR ALL OPENINGS REQUIRED IN MASONRY OR EXTERIOR WALLS UNDER THIS DIVISION. A QUALIFIED MASON AT THE EXPENSE OF THIS SUBCONTRACTOR SHALL REPAIR ALL OPENINGS TO MATCH EXISTING CONDITIONS.
4. Rigid polyvinyl chloride conduit (PVC) shall be installed when material surface temperatures and ambient temperature are greater than 40°F.
5. Where rigid polyvinyl chloride conduit (PVC) is used below grade, in a slab, below a slab, etc., a transition to rigid galvanized steel or PVC-coated steel conduit shall be installed before conduit exits earth. The metallic conduit shall extend a minimum of 6" into the surface concealing the non-metallic conduit.
6. Subcontractor shall provide suitable mechanical protection around all conduits stubbed out from floors, walls or ceilings during construction to prevent bending or damaging of stubs due to carelessness with construction equipment.

7. Subcontractor shall provide a polypropylene pull cord with 2000 lbs. tensile strength in each empty conduit (indoor and outdoor), except in sleeves and nipples.

### 3.4 UNDERGROUND CONDUIT INSTALLATION

#### A. Conduit Connections:

1. Conduit joints in a multiple conduit run shall be staggered at least one foot apart.

#### B. Conduit Bends (Lateral):

1. Conduits shall have long sweep radius elbows instead of standard elbows wherever special bends are indicated and noted on the drawings, or as required by the manufacturer of the equipment or system being served.
2. Telecommunications conduit bend radius shall be six times the diameter for conduits under 2" and ten times the diameter for conduits over 2". Where long cable runs are involved, sidewall pressures may require larger radius bends. Coordinate with Fermilab prior to conduit installation to determine bend radius.

#### C. Conduit Elbows (vertical):

1. Minimum metal or RTRC elbow radiuses shall be 30 inches for primary conduits (>600V) and 18 inches for secondary conduits (<600V). Increase radius, as required, based on pulling tension calculation requirements.

#### D. Conduit Placement:

1. Conduit runs shall be pitched a minimum of 4" per 100 feet to drain toward the terminations. Duct runs shall be installed deeper than the minimum wherever required to avoid any conflicts with existing or new piping, tunnels, etc.
2. For parallel runs, use suitable separators and chairs installed not greater than 4' on centers. Band conduit together with suitable banding devices. Securely anchor conduit to prevent movement during concrete placement or backfilling.
3. Where concrete is required, the materials for concreting shall be thoroughly mixed to a minimum f'c = 2500 and immediately placed in the trench around the conduits. No concrete that has been allowed to partially set shall be used.
4. Before the Subcontractor pulls any cables into the conduit he shall have a mandrel 1/4" smaller than the conduit inside diameter pulled through each conduit and if any concrete or obstructions are found, the Subcontractor shall remove them and clear the conduit. Spare conduit shall also be cleared of all obstructions.

5. Conduit terminations in manholes, masonry pull boxes, or masonry walls shall be with malleable iron end bell fittings.
6. All spare conduits not terminated in a covered enclosure shall have its terminations plugged as described above.
7. Ductbanks and conduit shall be installed a minimum of 24" below finished grade, unless otherwise noted on the drawings or elsewhere in these specifications.

**END OF SECTION 16111**

**SECTION 16121 - MEDIUM VOLTAGE CABLE****PART 1 - SCOPE**

- 1.1 INCLUDED: This Specification details the requirements for 15 kV, solid dielectric, ethylene propylene rubber insulation, triplexed aluminum cable with jacketed concentric, copper, neutral conductors. Cable shall be suitable for use on 13.8 kV, 60 hertz, solidly grounded systems.
- 1.2 CONDUCTOR SIZE: Refer to one line diagram for the conductor sizes and quantities.
- 1.3 INSTALLATION: Cable shall be suitable for installation in wet or dry locations, in an underground duct distribution system or direct buried in earth.
- 1.4 Medium voltage cable and termination kits will be provided by Fermilab, installed and wired by Electrical Contractor.

**PART 2 - CONDITIONS**

- 2.1 APPLICABLE STANDARDS: The publications listed below form part of this Specification. Each publication shall be latest revision and addendum in effect on the date of subcontract award, unless noted otherwise. Except as specifically modified by the requirements specified herein, the work included under this Specification shall conform to the provisions of these publications:

- A. AEIC (Association of Edison Illuminating Companies).
- B. ANSI (American National Standards Institute)
- C. ASTM (American Society for Testing and Materials).
- D. ICEA (Insulated Cable Engineers Association).
- E. NEMA (National Electrical Manufacturers Association).
- F. NFPA (National Fire Protection Association)
  1. NFPA 70 (National Electric Code)
- G. The Wire Association International "Electrical Wire Handbook."

Should a conflict occur between the above referenced standards, the AEIC standard will prevail. Any conflict, however, shall be brought to the attention of Fermilab.

This Specification shall be the operative norm where it exceeds the listed standards.

- 2.2 SUBMITTALS:

- A. Complete set of exceptions shall be submitted with the proposal and as follows:



1. Exceptions shall be specifically outlined, clearly explained, and supported with the necessary details, drawings and data.
  2. Any exceptions shall be cross referenced to the Specification and Specification paragraph number.
  3. Should no exceptions be taken to the Specification, a statement shall be provided indicating that no exceptions to the Specification are taken.
- B. Complete shop drawings shall be submitted for review in accordance with provisions included hereafter, showing compliance with all provisions of this Specification. The submittal schedule for these and other related documents is as follows:

Document

1. Exceptions to the Specification
2. Cable Construction Information
3. Cable Data and Information
4. Cable Test Procedures
5. Statement of Compliance
6. Proposed Steel Reel Sizes
7. Recommended cable testing procedure upon receipt.
8. Recommended cable testing procedure after 5 years service
9. Quality Assurance Program
10. Warranty Period and Coverage
11. Cable Construction Drawings
12. Certified Test Reports
13. Actual Shipping Length Report

The above listed drawings shall be submitted to Fermilab for Review.

- C. Subcontractor shall submit one (1) reproducible and one (1) copy of shop drawings as called for under the various headings of this Specification.
1. Subcontractor shall indicate, by signed stamp on the drawings, that the shop drawings have been checked for correctness, the work shown is in accordance with the subcontract requirements and that the drawings are dimensionally correct. These drawings shall contain all required detailed information.
  2. Shop drawings which relate to a complete assembly, structure or system with various parts shall not be submitted until all drawings required to completely detail that assembly structure or system are complete, so that the drawings may be reviewed in relation to each other.

- D. Fermilab will review the submittal documents for compliance with this Specification and will indicate approval or disapproval thereon.
1. If the submittals are "Approved as Submitted," Fermilab will return the reproducible to the Subcontractor who, in turn, shall be responsible for making and distributing prints to his organization.
  2. If the submittals are "Approved with Comments," Subcontractor shall revise the shop drawings to reflect the comments and resubmit one (1) reproducible and one (1) print following the procedure as described above. Fermilab, however, may clearly indicate that resubmittal of the documents is not required. Supplier may proceed with fabrication or manufacture, but shall not erect or assemble the equipment until the shop drawings have been resubmitted and approved by Fermilab.
  3. If the submittals are "Disapproved," the reason will be indicated on the reproducible and returned to the Subcontractor who shall expeditiously revise the submittals to comply with the Specification requirements. Subcontractor shall resubmit one (1) reproducible and one (1) print following the procedure as described above. Approval of the submittal documents by Fermilab shall not relieve the Subcontractor from meeting any of the requirements of this Specification.
- E. Each submittal shall have the following information clearly marked:
1. Medium Voltage Power Cable.
  2. The name of the Subcontractor - Fermi National Accelerator Laboratory
  3. The name of the Supplier.
- F. Catalog cuts and brochures which are not in reproducible copy are acceptable material for submittal for review and are to be submitted as prescribed in the above procedure for shop drawings, except that six (6) copies of all such material shall be required.
1. Two (2) copies will be returned to the Subcontractor upon completion of Fermilab review.
  2. Material shall be identified as described above by either printing thereon or by affixing a separate sheet thereto.
  3. One (1) reproducible and one (1) print of the submittal form prescribed above shall accompany the material.

### 2.3 QUALITY ASSURANCE:

- A. Only firms regularly engaged in the manufacture of cable assemblies and who have cable assemblies in satisfactory use in similar service for at least fifteen (15) years shall be considered acceptable manufacturers.
- B. Manufacturer shall maintain a Quality Assurance program during the fabrication and assembly of cable assemblies. All quality inspection records signed by the

Quality Control Inspector shall be available for Fermilab's review. Fermilab reserves the right to visit and inspect the manufacturing operation.

- C. Manufacturer shall submit a copy of the quality assurance program with proposal to ensure a product of highest quality will be provided.
- D. Insulation compounding shall be done at the cable assembly facility in an enclosed environment to prevent contamination.

2.4 **PRODUCT DELIVERY, HANDLING AND TAGGING:** Upon successful completion of testing and inspection requirements described herein, delivery shall be made according to the following:

- A. Cables not meeting this specification shall not be shipped by the Supplier. Cables shipped which are found not in compliance with this specification will be rejected by Fermilab and returned, at no cost to Fermilab, to the Supplier.
- B. Cables shall be shipped on non-returnable steel reels. Steel reels shall have a maximum outside width of 68 inches. Fermilab shall provide the supplier with steel reels for exchange purposes. The supplier shall be responsible for loading of exchange reels at Fermilab.
- C. Cables shall be furnished on reels with lengths as specified. Cable furnished in lengths shorter than specified, will be rejected and cable furnished in lengths longer than specified shall not result in any additional charges to Fermilab.
- D. Cable shall be shipped in one continuous length per reel.
- E. Heat shrinkable, watertight seals shall be furnished to all cable ends.
- F. Each cable reel shall be provided with a permanent tag on each flange with the identification number that appears on the test reports.
- G. Each reel shall be permanently marked on both the inside and outside of one reel flange with the manufacturers name, cable length, designation, weight, footage markers, and Fermilab purchase order number and date of shipment.
- H. Each reel shall be furnished with a pulling eye.
- I. The cable manufacturer shall indicate the firm cable delivery date in calendar days after receipt of order (to Fermilab's receiving dock).

### **PART 3 - MATERIALS**

3.1 **RATINGS:**

- A. Cable assemblies shall operate on a 13.8 kV (phase-to-phase), 60 hertz, wye connected, solidly grounded system.
- B. Cable shall be rated 15 kV.

3.2 **CENTER CONDUCTOR:**

- A. The center conductor shall be uncoated, electrical grade aluminum alloy 1350, three-quarter hard drawn, H16 Grade temper meeting the requirements of ASTM for tensile, elongation and brittle requirements.
- B. The conductor shall be concentric lay Class B stranding with 1% to 3% compressed concentric lay.
- C. Compatible semiconducting, high viscosity compounds shall be used to completely fill the interstices of the stranded conductors.
- D. The conductor shall have a minimum tensile strength as prescribed by ASTM standards.
- E. Splicing of conductors is strictly prohibited. Cables shall be shipped in continuous unspliced lengths.

### 3.3 STRESS CONTROL LAYER (CENTER CONDUCTOR SHIELD):

- A. Center conductor shield shall be extruded, conducting or preferably non-conducting, thermosetting compound with a minimum average thickness of 18 mils. Supplier shall distinguish at the time of bid whether the center conductor shield is conducting or non-conducting.
- B. Stress control layer material shall be compatible with conductor and insulation materials.
- C. Stress control layer material shall have an allowable operating temperature at least equal to that of the insulation system.
- D. Stress control layer shall be bonded to the overlying insulation yet be easily removed from the conductor without leaving residues.

### 3.4 INSULATION:

- A. The insulation shall be ethylene propylene-rubber resistant to heat, moisture, impact, ozone and discharge.
- B. The insulation system shall be suitable for a minimum continuous conductor temperature of 90°C, an emergency temperature of 130°C and short circuit temperature of 250°C. At the time of quotation, the cable supplier shall clearly indicate the cable thermal specifications (continuous, emergency, and short circuit) of the product they are proposing.
- C. The minimum average thickness of the insulation shall be 175 mils.
- D. Insulation physical and electrical properties shall be in accordance with ICEA Paragraph 3.6 (Type 1 Insulation).
- E. Insulation shall contain no polyethylene compounds.

### 3.5 INSULATION SHIELD:

- A. The insulation shield shall be an extruded thermosetting semiconducting compound.
- B. Insulation shield physical and electrical properties shall be in accordance with AEIC requirements.
- C. Insulation shield shall be free-stripping leaving no conducting particles or residue on the insulation surface.
- D. Insulation shield shall be identified as being conductive.

### 3.6 CONCENTRIC NEUTRAL CONDUCTORS:

- A. Concentric neutral conductors shall be solid, bare, annealed, uncoated, round copper spirally applied over the insulation shield with uniform spacing between wires.
- B. Concentric neutral conductors shall be provided in accordance with ICEA S-68-516 Table 7.6.5 and twenty-four (24) #12 AWG conductors shall be provided.
- C. The concentric neutral spacing shall be uniform with the length of lay not less than six (6) nor more than ten (10) times the diameter over the concentric wire layer.

### 3.7 JACKET:

- A. A non-conducting encapsulating linear, low-density, polyethylene jacket shall be provided over the concentric neutral conductors.
- B. Jacket shall be in accordance with ICEA and AEIC Standards.

### 3.8 IDENTIFICATION:

- A. All cable shall be identified by means of surface printing to indicate:
  - 1. Manufacturer's name.
  - 2. Cable size.
  - 3. Insulation type and thickness.
  - 4. Voltage rating.
  - 5. Year of manufacture.
  - 6. Sequential footing marking.

### 3.9 TESTING AND QUALITY ASSURANCE FOR EACH REEL: All testing as noted in this section pertains to factory tests conducted at the time of manufacture. Results of these tests will be made available to the Fermilab Standards Engineer prior to the shipment of cable reels as noted in Appendix II requirements to the supplier.

- A. Insulating shield stripping tests:
  - 1. The semiconducting or non-conducting material shall be cut longitudinally using a scoring tool radial depth of one (1) mil less than the minimum point.

A second parallel cut shall be made radially 1/2" from the first cut. The shielding shall be removable for 12" of length without tearing or leaving conducting material on the insulation. Stripping tension shall be 20 lbs. (maximum).

- B. The completed cable shall be tested in accordance with Sections E and F of AEIC CS6 for ac voltages only.
  - 1. The partial discharge shall be 5 pC or less for all voltages. Manufacturer shall provide X-Y plots as part of the certified test reports or the cable insulation shall be qualified using the ASTM D2275-89 "Standard Test Method for Voltage Endurance of Solid Electrical Insulating Materials Subjected to Partial Discharges (Corona) on the Surface".
- C. An inspection shall be made and reported for the surface of each conductor to assure that the outer surface of the conductor is clean and free of water blocking compound or any foreign matter.
  - 1. A water penetration test shall be made for each shipping reel to assure that each stranded conductor is properly filled with an approved water blocking compound.
  - 2. Test results for water penetration tests and inspection of conductor surface shall be included as part of the certified test reports.
- D. A water migration test shall be provided at least once for each cable shipment or at intervals of each 25,000 conductor feet as an on-going performance indicator of the longitudinal water blocked jacket. Results shall be included as part of the certified test report.
- E. Certified test reports shall be forwarded with each reel and shall include oscillograms, test reports, and drawings required to comply with this Specification.
- F. Fermilab reserves the right to witness all testing, and shipment commitments shall allow five (5) days for advance notification.

#### **PART 4 - WARRANTY**

- 4.1 Cable being proposed shall include warranty period and coverage. Cable shall be designed and manufactured to provide a life expectancy for a minimum 40 year period commencing upon delivery to Fermilab. The Subcontractor shall clearly indicate the cable manufacturer's inclusive warranty period and conditions for the cable being supplied to Fermilab. Replacement costs associated with premature cable failure due to inadequate design or faulty manufacturing shall be the full responsibility of the Subcontractor.
- 4.2 **WARRANTY CABLE REPLACEMENT:** The following describes the special conditions associated with a cable failure and warranty replacement. It is intended as a guideline should a cable fault occur and Fermilab determines that it may have resulted from a manufacturing defect.

- A. Definition of a cable segment:
  - 1. A cable segment is a single or triplex cable from the termination point on one end to the termination point on the other end.
  - 2. A stand alone single-faulted cable or a single-faulted cable within a triplex bundle that may be direct buried, in PVC conduit, or in a ductbank.
  - 3. If a single conductor of a triplex group has faulted, then the entire triplex bundle (a triplex cable section) is considered failed at that point due to thermal stresses.
  
- B. Test of faulted segment:
  - 1. When a cable segment has failed, Fermilab will remove the faulted section. This faulted segment will be sent by Fermilab to an independent testing laboratory for analysis.
  - 2. The independent test laboratory will test the faulted cable segment to determine why the cable failed. If the failure is determined to have resulted due to a manufacturing failure in the insulation or protective jacket, cable replacement by the manufacturer will be handled as noted in (c) below.
  
- C. Cable replacement by the manufacturer:
  - 1. A cable segment determined to have faulted because of a manufacturing defect will be replaced in its entire segment length (single or triplex) by the cable manufacturer. This replacement will include all costs associated with manufacturing, manufacturer's required testing, cable reel, and delivery charges (i.e., f.o.b. Fermilab shipping dock).

## **PART 5 - SUPPLEMENTARY SPECIFICATION**

- 5.1 ICEA/NEMA Standards Publication for Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy, ICEA Publication No. S-68-516, NEMA Publication No. WC8.
- 5.2 NEMA Standards Publication for Wire and Cable Packaging, WC-26.
- 5.3 ANSI Standard C2, National Electric Safety Code.
- 5.4 ANSI Standard C119.4, Connectors for Use Between Aluminum-to-Aluminum or ICEA Publication T-31-610, Guide for Performance Of a Longitudinal Water Penetration Test for Sealed Conductor.

**END OF SECTION 16121**

## **SECTION 16125 - 15KV CABLE INSTALLATION**

### **PART 1 - GENERAL**

#### **1.1 SCOPE OF WORK**

- A. This Section prescribes the general requirements for 15kV CABLE INSTALLATION. Subcontractor shall furnish the materials, installation, terminating, splicing, testing and all related work for the complete and functional 15kV cable system, as specified herein and as shown on the Subcontract drawings.
- B. This Section prescribes the general requirements for 15kV switches and 15kV-480V transformer installation. Subcontractor shall furnish, installation, connection, testing and all related work for the complete and functional 15kV distribution system, as specified herein and as shown on the Subcontract drawings.
- C. Connection of ground conductors to the electrical equipment shall be included as part of this Work.
- D. The drawings and Sections are meant to complement each other; however, in case of conflicts, the sections shall govern, since they are intended to identify all materials and equipment required for the construction of the facility. Any deviation from the Sections or drawings shall be authorized by the Fermilab Construction Coordinator prior to purchase or installation.
- E. Any apparatus, appliance, material, or work not shown on drawings or indicated in the Sections, but necessary to make the work complete and ready for operation shall be furnished, delivered, and installed by Subcontractor without additional expense to Fermilab.

1.2 The work of this Section is subject to the Fermilab Construction Subcontract Terms and conditions and to Exhibit A, SCHEDULE AND SUPPLEMENTARY TERMS AND CONDITIONS.

1.3 RELATED WORK: Examine all other portions of the Subcontract documents for work related to the work of this Section. Provide all work hereunder as required for the support and accommodation of related work.

1.4 RELATED WORK SPECIFIED ELSEWHERE: The following Sections prescribe items of related Work. Coordinate Work prescribed by this Section with Work prescribed by these Sections:

- A. Section 16010 - General Electrical Requirements
- B. Section 16060 - Grounding and Bonding
- C. Section 16080 - Electrical Inspection and Testing



- D. Section 16100 - Ductbank
  - E. Section 16215 - 14.4 kV Pad Mounted Air Switch
- 1.5 APPLICABLE STANDARDS: The publications listed below form part of this Section. Each publication shall be the latest revision and addendum in effect on the date of the subcontract award, unless noted otherwise. Except as specifically modified by the requirements specified herein or the details on the drawings, the Work included under this Section shall conform to the provisions of these publications:
- A. ANSI (American National Standards Institute)
    - 1. ANSI C2 (National Electrical Safety Code)
  - B. ICEA (Insulated Cable Engineers Association)
  - C. IEEE (Institute of Electrical and Electronics Engineers)
  - D. NEMA (National Electrical Manufacturers Association)
  - E. NETA (National Electrical Testing Association)
  - F. NFPA (National Fire Protection Association)
    - 1. NFPA 70 (National Electrical Code)
  - G. OSHA (Occupational Safety and Health Administration)
  - H. UL (Underwriters' Laboratories, Inc.)
- 1.6 SUBMITTALS: The following submittal documents shall be furnished prior to equipment installation:
- A. Physical dimensions and weights.
  - B. Connection diagrams.
  - C. Certified test reports.
  - D. Certificate of NEMA compliance.
  - E. Statement of Section compliance
  - F. As-Built Drawings:
    - 1. A complete set of electrical drawings shall be maintained by the Subcontractor at the job-site for "as-built" records. These prints shall be corrected daily to show any deviations from the subcontract drawings, accurately indicating locations of all splices and actual installed cable lengths. A legible set of these "as-built" drawings shall be submitted to the Fermilab Construction Coordinator at the completion of the Subcontract.

- G. Submittals shall be in accordance with Section 16010: ELECTRICAL – GENERAL REQUIREMENTS and the following:
  - 1. At least ten (10) days prior to the procurement of the equipment or material or installation thereof, and at most thirty (30) days after Subcontract award, Subcontractor shall submit a type written list of all items of equipment and material proposed for the project. The list shall set forth the Section page number, manufacturer's name, model number, size, non-standard accessories specified or required and any other information required to identify each item. If substitutions have been offered in lieu of the specified materials and/or equipment, complete descriptive literature for those substitute items shall be submitted. Substituted items shall require approval by Fermilab.

#### 1.7 QUALITY ASSURANCE AND CONTROL:

- A. Subcontractor shall be responsible for quality control and construction inspection in accordance with Exhibit A.
- B. All work is subject to the final acceptance by Fermilab. Strict conformance to the drawings and sections shall be required.
- C. Only firms regularly engaged in the construction and installation of medium voltage cable installations and terminations and who have their systems in satisfactory use in similar service for at least ten (10) years shall be considered acceptable Subcontractors.
- D. Performance Guarantee:
  - 1. Installation of electrical systems shall be completed to the satisfaction of Fermilab Construction Coordinator. The Subcontractor, at no additional cost to the Fermilab, shall correct work performed by the Subcontractor judged not to be to the satisfaction of the Fermilab Construction Coordinator.
  - 2. It shall be the sole responsibility of the Subcontractor that the electrical systems are installed to the satisfaction of Fermilab.
  - 3. Subcontractor shall guarantee all equipment, material, and installation provided by Subcontractor to be free from defects.
  - 4. Subcontractor shall assign persons in direct charge of the work who are thoroughly experienced in the class of construction required. All labor shall be performed in a workmanlike manner by skilled workmen under supervision of a competent foreman.
- E. Electrical Equipment:
  - 1. Fermilab will perform any and all cable de-energization. Subcontractor is prohibited from performing any circuit switching.

## PART 2 - PRODUCTS

## 2.1 MATERIAL

### A. Terminal Lugs:

1. Subcontractor shall furnish and install lugs for the termination of power cables at electrical equipment (except oil switch terminations). Terminal lugs shall be un-insulated, aluminum compression terminal with NEMA 2-hole pattern. Lugs shall be suitable for aluminum cable and shall be as manufactured by Burndy. Terminal lugs shall be as follows:

- |    |                        |            |
|----|------------------------|------------|
| a) | Conductor Size:        | 750 MCM    |
|    | Straight Connector:    | YA39AM2    |
|    | Angle (45°) Connector: | YA39AM2-45 |
| b) | Conductor Size:        | #4/0 AWG   |
|    | Straight Connector:    | YA28A5     |
|    | Angle (45°) Connector: | YA28A5-45  |

### B. Termination Kits-Air:

1. Termination kits for new air switches or transformer terminations shall be 3M Company Cold Shrink QT III Termination Kits and as follows:

#### 15kV Concentric and Jacketed Concentric Cable Kits:

Conductor Size:	500 MCM – 1000 MCM
Conductor Insulation O.D. Range:	1.05"-1.80"
Indoor Kit Number:	7645-T-110
Outdoor Kit Number:	7655-S-4

Conductor Size:	#2 - 4/0; 2/0 – 300 MCM
Conductor Insulation O.D. Range:	0.64" - 1.08; 0.72"-1.29"
Indoor Kit Number:	7642-T-110
Outdoor Kit Number:	7653-S-4

2. Outdoor kits shall be utilized when the termination is exposed to the weather.
3. Termination kits shall be furnished and installed by Subcontractor. Subcontractor shall exercise extreme care in conductor preparation and insulation strip lengths.

### C. Cable Splice Kits:

1. Cable splice kits shall be as manufactured by Elastimold as follows:

- |    |                       |                  |
|----|-----------------------|------------------|
| a) | In-Line Splice Kits:  |                  |
|    | Conductor Size:       | 750 MCM          |
|    | Conductor Size Range: | 1.370"-1.630"    |
|    | Splice Kit Number:    | 650S-M0380-M0380 |

Splice Barrel Length: 6.75"

b) Wye Splice Kits:

Conductor Size: 750 MCM  
Conductor Size Range: 1.370"-1.630"  
Splice Kit Number: 656CY-M0380

2. Splice kits shall be furnished and installed by Subcontractor. Subcontractor shall exercise extreme care in conductor preparation and insulation strip lengths.

D. Power Manholes (PMH):

1. Unless noted otherwise on the subcontract drawings, all manholes are existing and in-place.
2. Subcontractor shall be forewarned that:
  - a) Cable supports in existing manholes have deteriorated.
  - b) Removal and installation of cables in manholes will be difficult due to the number and routing of existing cables.
  - c) All manholes should be assumed to full of water and pumping will be required.
  - d) Adjacent feeders in the manholes will be energized. Subcontractor agrees that work can be performed in manholes with energized adjacent feeders. NO EXCEPTIONS.

E. Cable Racks:

1. For new work and where indicated on the drawings, heavy duty non-metallic cable racks shall be installed in manholes for cable support.
  - a) Stanchions and arms shall be made from 50% glass-reinforced nylon. The station shall be 36 inches long, shall incorporate multiple arm mounting holes 4 inches apart and recessed bolt mounting holes. Cable rack arm lengths shall be appropriate to the manhole size and amount of cable being installed. Cable rack assembly shall meet or exceed the anticipated load capacity.
  - b) Drop-in anchors, screws, and washers used for mounting stanchions shall be made from corrosion resistant type 316 stainless steel.

F. Raceways and Concrete Pads:

1. Subcontractor shall furnish and install 15kV concrete encased, electrical duct banks and concrete pads as shown on the Subcontract drawings.

**G. Core Drills:**

1. Subcontractor shall provide all requirements for the core drilling of existing manholes where duct terminators are not available.
2. Subcontractor shall:
  - a) Furnish and install conduit end bells for all conduits terminating in a manhole. End bells shall be grouted with lean grout.
  - b) Furnish a sketch of proposed locations of all core drills to the Fermilab Construction Coordination prior to the beginning of any manhole cores.

**H. Firewrapping:**

1. All power cables in manholes and cable vaults shall be suitably protected against fire. Entire length of exposed cable in the manhole (including splices and/or wye splices) shall be firewrapped. Cable firewrapping shall be furnished and installed by the Subcontractor.
2. Firewrapping shall be as manufactured by 3M Company (3M-77) or Fermilab approved equal.

**I. Grounding Materials:**

1. Bonding and grounding conductors shall be ASTM B1 solid, bare copper for sizes #8AWG and smaller and shall be ASTM B8 Class B stranded copper for sizes #6AWG and larger.

**PART 3 - EXECUTION**

- 3.1 All bus, insulators and other exposed hardware shall be cleaned by the Subcontractor.
- 3.2 Subcontractor shall take the necessary construction and safety precautions during the installation of the new cables in the manholes or other areas where the energized feeders are located.
- 3.3 The drawings indicate the general layout of the electrical systems, arrangement of feeders, substations, and other work. Electrical plans are by nature diagrammatic.
  - A. Subcontractor shall bring to Fermilab's attention any discrepancies between the drawings and the "As-Constructed" conditions. Subcontractor shall not deviate from the drawings without written approval from the Fermilab Construction Coordinator.
  - B. Subcontractor shall verify the location and method for connecting to each item of equipment.
  - C. Subcontractor shall install equipment and material in accordance with the Subcontract requirements. Materials or equipment improperly installed shall be

removed and reinstalled to the satisfaction of Fermilab Construction Coordinator, at Subcontractor's expense

- D. All cables shall be routed for ease of maintenance, serviceability, and installation of future cables.
- E. Whenever possible, cables routed in manholes shall enter and exit the manholes penetrations through corresponding conduits on the opposite sides of the manhole.

### 3.4 Cable Reel Movement:

- A. Reels of cable shall not be dropped from any heights. Particular care shall be exercised when handling reels from trucks or other transporting equipment.
- B. Reels shall be lifted utilizing the following methods:
  - 1. When using a crane or boom type equipment, insert a heavy rod or pipe through the reel hub and lift with slings on shaft, preferably using a spreader bar or yoke to reduce or avoid side pressure against the reel flange.
  - 2. Fork lift type equipment may be used to move smaller, narrower width reels. Fork tines shall be placed such that the lift pressure is on the reel flange and not on any part of the cable and the tines shall reach across the reel on both flanges of the reel.
  - 3. Reels may be rolled short distances by rolling. Reels shall be rolled in the direction of the arrows marked on the reel flanges. Surfaces over which the reels are rolled shall be firm, clear of debris, and clear of protruding stones, humps, etc. which might otherwise damage the cable.

### 3.5 Cable Storage:

- A. Should the cable end seals be damaged or removed, Subcontractor shall install new seals to prevent entry of moisture. Cable seals shall be sealed using RayChem heat shrink end seals.
- B. Whenever possible, factory installed lagging (protective cover), if provided, shall be left in place. Additional covering shall be provided and installed by the Subcontractor if the cable reels are stored outdoors for excessively long periods (more than seven calendar days) or in dirty or dusty areas.
- C. Cable reels shall be stored on a firm surface with planking to prevent settling of the cable reels into soft ground.
- D. Any area of cable reel storage shall have adequate drainage. Subcontractor shall relocate any and all cable reels located in areas of inadequate drainage.
  - 1. Fencing or other barriers shall be provided by the Subcontractor to protect reels against damage.

### 3.6 Cable Placement:

- A. Conductor/cable installation shall be in accordance with the cable manufacturer's recommendations and the following requirements:
1. Cable shall not be handled when the cable temperature is below 32°F (0°C). If cable heating is required prior to placement, the cable shall be stored in a heated building in accordance with the manufacturer's recommendations for a minimum of 24 hours. Cable shall be pulled the same day it is removed from the heated storage. Subcontractor shall provide temporary shelter and heating for cables and reels.
  2. If at any time during the progress of the work the Subcontractor finds raceways that appear inadequate to accommodate the assigned cable, he shall notify Fermilab at once and shall discontinue any further work on the questionable raceway until advised by Fermilab as to how to proceed.
  3. Immediately prior to the placement of each cable or cable group, the raceway route to be followed shall be inspected and ascertained to be complete in installation and free of all materials detrimental to the cable or its placement. All cable assigned to a particular conduit shall be grouped and pulled in simultaneously using cable grips and acceptable lubricants.
    - a) Subcontractor shall pull an appropriate sized mandrel through conduits prior to pulling any cables.
  4. All cable shall be carefully checked both as to size and length before being pulled into conduits. Cable pulled into the wrong conduit or cut too short to rack, train, and splice as specified herein shall be removed and replaced by and at the expense of the Subcontractor. Cable removed from one conduit shall not be pulled into another conduit.

### 3.7 Cable Pulling:

- A. Damaged cable shall be removed and replaced by and at the expense of the Subcontractor.
- B. Pulling eyes on conductors or a basket weave grip shall be used for pulling cable. Woven wire cable grips shall be used to pull all single conductor cable where pulling eyes are not available. All sharp points and edges on the hardware attaching the pulling rope to the cable shall be taped to prevent snagging or damaging the raceway. Pulling eye only shall be utilized for pulling of 15kV 750kcmil cables.
- C. When a cable grip or pulling eye is used for pulling, the area of the cable covered by the grip or seal plus 6" shall be cut off and discarded when the pull is completed. When pulling loops are used, the entire loop shall be cut off and discarded when the pull is completed.
- D. A nonfreezing type of swivel, or swivel connection, shall be inserted between the pulling rope and the cable pulling eye, grip, or loop to prevent twisting under strain and to allow for free rotation of the cable during pulling.

- E. Cable pulling compounds shall not contain microball spheres, ethylene glycol or mineral oil. Acceptable pulling compound shall be as manufactured by American Polywater Corp. (Polywater J) or Fermilab approved equal.
- F. As soon as the cable is pulled into place, the pulling eyes, cable grips, or pulling loops shall be removed. Any cable which was sealed shall be resealed.
  - 1. Cables pulled with ends pulled to a point above normal grade elevation shall be resealed with a minimum of three (3) wraps of 2" Scotch #23 (or Fermilab approved equal) rubber splicing tape. Exposed cables ends shall be carefully wrapped in such a manner as to prevent unintentional water entry from weather exposure. Exposed cable ends shall be wrapped prior to the end of the work day.
  - 2. Cables pulled with ends pulled to a point below normal grade elevation (manholes or vaults) shall be resealed with appropriately sized RayChem heat shrink end seal boots. Exposed cables ends shall be sealed in such a manner as to prevent unintentional water entry from weather or water filled manholes or vaults. Exposed cable ends shall be sealed prior to the end of the workday.

### 3.8 Pulling Tension:

- A. The pulling tension of any cable shall not exceed the maximum tension recommended by the cable manufacturer. Pulling mechanisms of both the manual and power types used by the Subcontractor shall have the rated capacity in tons clearly marked on the mechanism. Whenever the capacity of the pulling mechanism exceeds the recommended pulling tension of the cable as given by the cable manufacturer, a dynamometer shall be used to show the tension on the cable and the indicator shall be constantly watched. If any excessive strain develops, the pulling operation shall be stopped at once and the difficulty determined and corrected.

### 3.9 Sidewall Pressure:

- A. To avoid insulation damage from excessive sidewall pressure at bends, the pulling tension in pounds at a bend shall not exceed 300 times the radius of the bend in feet.

### 3.10 Cable Bends:

- A. Cable shall not be bent to a radius of less than 12 times the overall cable diameter.

### 3.11 Hi-Pot Testing:

- A. All cables shall be tested in accordance with the requirements of Section 16080: ELECTRICAL TESTING AND INSPECTION.
- B. Hi-pot test voltages shall be as follows, unless directed otherwise by the Fermilab Construction Coordinator:



1. 15kV Unjacketed Cable: 65kV in 10 increments of 6500V.
  2. 15kV Jacketed Cable: 55kV in 10 increments of 5500V.
- C. Cable testing shall be performed under this Subcontract and shall meet the requirements of NETA (National Electrical Testing Association). See Section 16080: Electrical Testing and Inspection for cable testing parameters and requirements to be provided under this Subcontract.

### 3.12 Terminations:

- A. Cable shall be terminated in accordance with the following requirements:
1. Cable shall be neatly trained in place and cut squarely to the required length. Sharp bends shall be avoided.
  2. Remove necessary amount of cable jacket and insulation without damage to the conductor.
  3. Install terminals or terminal connectors as required, ensuring a firm metal-to-metal contact.

### 3.13 Cable Supports-General:

- A. Cable supports and securing devices shall be installed to provide adequate support without deformation of the cable jackets or insulation.
- B. Adequate cable end lengths shall be provided and properly placed in manholes to avoid longitudinal strains and distorting pressures on the cable.
- C. Cable routing in manholes shall be subject to the approval of the Fermilab Construction Coordinator.
1. Cables shall be routed within the manhole such that adequate working space is provided within the manhole for cable splicing and for the installation of future cables.
- D. Cables shall be tied through the use of cable ties, however, installation shall not impede horizontal movement of cables during ambient variations and short circuit forces.
- E. Final inspection shall be made after all cable is in place and, where supports or raceway fittings deform the cable jacket, additional supports shall be provided as directed by Fermilab. Additional cable protection such as a wrapping of light rubber belting, friction tape or similar material shall be provided where required.

### 3.14 Lacing:

- A. Nylon ties shall be used to neatly lace together conductors entering manholes, handholes and similar locations after the conductors have emerged from their raceway.

## 3.15 Grounding:

- A. Concentric neutrals shall be grounded at all splice points and at all termination points.
- B. Concentric neutrals shall be pulled back, twisted together and connected to the grounding conductor using a compression type ground lug.
- C. Concentric neutral from splice or termination shall be grounded to the system ground through the use of a 500 kcmil bare copper ground cable.
- D. Ground conductors shall not be looped between pieces of cable. Each cable ground point shall have a direct connection to the ground system.
- E. All contact surfaces shall be thoroughly cleaned of dirt or oil.
- F. Grounding circuit connections shall be such that grounding resistance may be checked at anytime.

## 3.16 Cable Identification:

- A. Subcontractor shall identify furnish and install cable identification markers near each termination point and at each manhole or handhole of all conductors.
- B. Each cable shall bear the number of the circuit and the "from" - "to" routing of the cable. For example:

FDR 31  
PHP P-115 TO MS2

Nameplate engraving shall be subject to the approval of the Fermilab Construction Coordinator.

- C. All cables shall be identified with machine engraved lamocoid nametags with white letters on red background and shall be firmly attached to the cable with non-metallic cable ties.
- D. Each nameplate shall be provided with a 1/4" diameter hole for securing the nameplate to the cable.
- E. Nametags shall be approximately 1 1/2" wide and of sufficient length to accommodate the lettering requirements. Lettering shall be as follows:
 

First line (Feeder number):	1/2" lettering.
Second line (From-To):	3/8" lettering.
- F. Phase identification tags shall be provided at all termination points. Phase identification shall be as follows:
 

1. A Ø (Ungrounded conductor):	Black
2. B Ø (Ungrounded conductor):	Red

3. C Ø (Ungrounded conductor): Blue

G. Equipment Identification: All electrical equipment and enclosures shall be identified with nameplates. Nameplates shall be machine engraved lamocoid with white letters on black background. Nameplates shall be attached with 3M 9500PC, double side, adhesive tape for indoor locations and with self-tapping stainless screws for outdoor locations. Nameplates shall be as follows:

H. 4-Way Disconnect Switch:

1. Master Nameplate:

- a) Nameplate Size: 6" x 3" x 1/4"  
 Lettering Size: 3/4"
- b) Nameplate shall be attached on disconnect such that the nameplate of the transformer and nameplate of disconnect switch can be viewed from the same direction.
- c) All disconnect switches requiring termination of 15kV cables and conductors shall be provided with nameplates.
- d) Nameplate engraving and location shall be subject to the approval of the Fermilab Construction Coordinator.

2. Quadrant or Compartment Nameplate

- a) Each disconnect switch, as described above, shall be furnished with an additional nameplates for each compartment. One (1) nameplate shall be installed on each switch compartment.

Disconnect Switches Compartment:

Nameplate Size: 4" x 2"  
 Lettering Size: 1/2"

- b) Nameplate shall be provided with the feeder number and the destination of the cable terminated at the switch. For example, one of the compartments of disconnect switch MDW shall be furnished with the following nameplate:

Compartment 1:  
 FDR. 31  
 MASTER SUB

Compartment 2:  
 FDR. 30  
 MASTER SUB

Compartment 3:  
 FDR. TO  
 ML-6

Compartment 4:  
 FDR. TO  
 ML-5, 10, 14

All nameplate engraving and location shall be subject to the approval of the Fermilab Construction Coordinator.

**3.17 Cable and Cable Reel Disposition:**

- A. Any cable removed shall remain the property of Fermilab.
  - 1. Subcontractor shall coordinate removal of cable with the Fermilab Construction Coordinator for the determination of posted radiological areas.
  - 2. All other excess (removed) aluminum or copper cable shall be cut into approximately 6 foot pieces and placed into fermilab designated containers.
- B. Subcontractor shall return steel cable reels to the railyard storage area. Fermilab will return the empty reels to the Manufacturer at the end of the Subcontract for reel deposit.
  - 1. Empty wood cable reels shall be demolished and disposed by the Subcontractor.

**END OF SECTION 16125**

**SECTION 16215 - 14.4KV PAD MOUNTED AIR SWITCH****PART 1 - GENERAL****1.1 SCOPE OF WORK**

- A. This Section prescribes the general requirements for 14.4KV PAD MOUNTED AIR SWITCH. Subcontractor shall furnish air switch, all material, labor, equipment, transportation, supervision and services necessary for the installation and testing of the 14.4KV Pad Mounted Air Switch.
- B. Air switches shall be suitable for installation on Fermilab's 13.8kV, solidly grounded, 3Ø distribution system.
- C. Air switches will be provided by Fermilab, installed and wired by Electrical Contractor.

1.2 The work of this Section is subject to the Fermilab Construction Subcontract Terms and conditions and to Exhibit A, SCHEDULE AND SUPPLEMENTARY TERMS AND CONDITIONS.

1.3 RELATED WORK: Examine all other portions of the Subcontract documents for work related to the work of this Section. Provide all work hereunder as required for the support and accommodation of related work.

1.4 RELATED WORK SPECIFIED ELSEWHERE: The following Sections prescribe items of related Work. Coordinate Work prescribed by this Section with Work prescribed by these Sections:

- A. Section 16010 - General Electrical Requirements
- B. Section 16060 - Grounding and Bonding
- C. Section 16080 - Electrical Testing and Inspection
- D. Section 16125 - 15 kV Cable Installation

1.5 APPLICABLE STANDARDS: The publications listed below form part of this Section. Each publication shall be latest revision and addendum in effect on the date of Subcontract award, unless noted otherwise. Except as modified by the requirements specified herein, the equipment included under this Section shall conform to the provisions of these publications:

- A. ANSI (American National Standards Institute)
- B. IEEE (Institute of Electrical and Electronics Engineers)
- C. NEMA (National Electrical Manufacturers Association)

Should a conflict occur between the above referenced standards and this Section, the conflict shall be brought to the attention to Fermilab for resolution.

#### 1.6 SUBMITTALS:

- A. Submittal documentation shall be in accordance with Section 16010 and the following:
  - 1. Dimensional, outline and arrangement drawings, including weights.
  - 2. Base details with floor openings.
  - 3. Electrical ratings.
  - 4. Bill Of material.
  - 5. Installation, maintenance and operating manuals.
  - 6. A complete list of exceptions to the Section listed by section paragraph number or a written statement indicating complete compliance with the section.
  - 7. Description of Manufacturer's warranty.

#### 1.7 QUALITY ASSURANCE AND CONTROL:

- A. Subcontractor shall be responsible for quality control and construction inspection in accordance with Exhibit A.
- B. All work is subject to the final acceptance by Fermilab. Strict conformance to the drawings and sections shall be required.
- C. Only firms regularly engaged in the manufacture of pad mounted air switches, who provide sales and spare parts, and who have had their switches in satisfactory use in similar service for at least fifteen (15) years shall be considered acceptable manufacturers.
- D. Manufacturer shall maintain a quality assurance program during the fabrication and assembly of the disconnect switches. All quality inspection records signed by the Quality Control Inspector shall be available for Fermilab's review.
- E. All equipment and material rated 600V and under shall be labeled by UL (Underwriter's Laboratory). If such labeling is unavailable, the equipment and material shall be certified for use by an independent testing laboratory acceptable to Fermilab.
- F. Equipment and material rated above 600V shall be provided with supporting data to show conformity to recognized national standards such as ANSI, NEMA and IEEE.

#### 1.8 SHIPPING REQUIREMENTS:

- A. Switches shall be shipped as completely assembled units on wood pallets and equipped with hoist sling devices for movement by hoists or forklift truck.

## **PART 2 - PRODUCTS**

### **2.1 DESIGN REQUIREMENTS:**

- A. Voltage:
  - 1. Nominal: 14.4kV.
  - 2. Maximum: 17.0kV.
  - 3. Three phase, 60 Hertz.
- B. Current:
  - 1. Bus Rating: 600A.
- C. 20.0 kA symmetrical amps short circuit rating.
- D. 480 MVA symmetrical (at 13.8 kV).
- E. Insulation Level: 95kV BIL.
- F. Switch Type: 4-Way (Unfused).
- G. Bus: Aluminum (56% IACS conductivity).

### **2.2 SWITCH MECHANISM:**

- A. Each switch mechanism shall be operated by means of an externally accessible hex switch operating hub.
- B. Each switch mechanism shall be provided with one (1) folding switch operating handle. Operating shall be secured to the inside of the switch operating hub pocket.
- C. Switches shall utilize a quick-make, quick-break mechanism.
- D. Switches shall be provided with a single blade per phase for closing circuit, including fault closing and continuous current rating.
- E. Switch insulators shall be of a cycloaliphatic resin system.
- F. Switch terminal connections shall be suitable for bottom entry/exit, 750MCM, 15kV, aluminum conductors.
- G. When specified, lug adapters for suitable for installation of cables (2/Ø) shall be provided.
- H. Provisions for future kirk-key interlocking shall be included.

### 2.3 ENCLOSURE REQUIREMENTS:

- A. Switch enclosure shall be 11 gauge, hot rolled, pickled and oiled sheet steel approximately 67" wide x 64" deep x 68" high.
- B. All structural joints and butt joints shall be welded with all seams ground flush and smooth.
- C. Enclosure construction shall not utilize externally accessible hardware.
- D. Fiberglass, reinforced polyester, insulating, interphase and end barriers shall be provided.
- E. Full length and height steel barriers shall separate side-by-side compartments.
- F. Dual purpose, front barriers shall be provided for each switch compartment. Barriers (in their hanging position) shall guard against contact with energized parts. It shall be possible to lift and insert the barriers in the open gap for access to the switch mechanism.
- G. Window panels shall be provided to view switch position without removal of the dual purpose, front barriers.
- H. Welds along the bottom enclosure flange shall be coated with a wax based, anti-corrosion moisture barrier to provide corrosion resistance.
- I. One (1) ground pad shall be provided in each compartment of the switch. Pads shall be nickel plated, welded to the enclosure and coated with a uniform coating of an oxide inhibitor prior to shipment.
- J. A 24" high, steel, compartmented base spacer shall be provided for each switch.
  - 1. A resilient, closed cell PVC gasket shall be applied to the entire underside of the enclosure bottom flange to isolate the bottom flange from the concrete foundation.

### 2.4 DOORS:

- A. Doors shall be 11 gauge, hot rolled, pickled and oiled sheet steel.
- B. Each door shall be provided with a three (3) point, tamper resistant, automatic latching mechanism.
- C. A hex-head socket wrench or tool shall be required to actuate the latching mechanism.
- D. The latching mechanism shall be suitable for padlocking.
- E. All door hardware and mounting hardware shall be stainless steel.
  - 1. All mounting hardware shall not be externally accessible.



2. Cadmium plated ferrous parts shall not be used.

## 2.5 ENCLOSURE COATING AND FINISH:

- A. A heavy coat of insulating "non-drip" compound shall be applied to the underside of the roof to minimize condensation of moisture.
- B. Enclosure shall be given a pretreatment process of cleaning, rinsing, phosphotizing, sealing, drying, and cooling prior to the applicable of any protective coatings.
- C. After the pre-treatment process, the enclosure shall be finished coated with a minimum of two (2) coats of manufacturer's standard epoxy-enamel corrosion resistant coating system. Coating system shall satisfy the following criteria:
  1. 4000 hours of salt-spray testing per ASTM B 117.
  2. 1000 hours of humidity testing per ASTM D 4585.500 hours of accelerated weather testing.
  3. Cross hatch adhesion testing per ASTM D 3359 Method D.
  4. 160 inch-pound impact adhesion testing per ASTM D 2794.
  5. Oil resistance testing consisting of a 72 hour immersion bath in mineral oil with no shift in color, no streaking, no blistering and no loss of hardness.
  6. 3000 cycles of abrasion testing per ASTM 4060.
- D. Custom finish color shall be selected by Fermilab.
- E. Certified tests substantiating the above tests shall be furnished upon request.

## 2.6 WARNING TAGS:

- A. Warning tags shall be provided on the inside and outside of the enclosure.

## 2.7 NAMEPLATES:

- A. Nameplates shall be furnished on the outside of the enclosure with the following minimum information:
  1. Manufacturer's name.
  2. Date of manufacture.
  3. Catalogue number.
  4. Model number.
  5. Serial number.

## 2.8 ACCEPTABLE MANUFACTURERS:

- A. Only after compliance with all provisions of this Section, the following manufacturer of 4-way switch will be considered:
  - 1. S&C Model PMH-10 (#55242-R3) with options:
    - a) B1: Hex-head actuator.
    - b) K4: 24" Base spacer.
    - c) B6: Reinforced bus (480MVA)

## PART 3 - EXECUTION

- 3.1 Subcontractor responsible for the installation of the 4-way switch shall provide for the grounding of the switch.
- 3.2 A ground loop shall be installed around the perimeter of the switch pad with connections to the quadrants of the 4-way switch. Grounding shall be as follows:
  - A. Ground loop shall be 500 kcmil bare copper. Ground taps connections to the 4-way switches shall be 500 kcmil bare copper.
  - B. The ground loop conductor shall be located a minimum 30" outside the perimeter of the concrete pad and a minimum 18" below grade level to the top of the ground rod.
  - C. Each quadrant of every 4-way switch shall be provided with capabilities for connection to the ground grid system, minimum of four (4) places. Ground connections from the ground grid to 4-way switch ground pads shall be 500 kcmil bare copper. Subcontractor shall provide connections to the ground grid from the 4-way switch in compartments provided with ground lugs. Ground cables in compartments with no ground lugs shall be utilized for cable shield grounds.
  - D. Installation and routing of ground conductors shall not interfere with the installation of the phase conductors.
  - E. Ground conductors shall not be looped between pieces of equipment. Each ground point shall have a direct connection to the ground system.
  - F. Ground rods shall be installed at the corners of the ground loop and at intervals not exceeding 20'-0".
- 3.3 Refer to Section 16125: 15kV CABLE INSTALLATION for 4-way switch identification requirements to be provided by the Subcontractor.

**END OF SECTION 16215**

## **SECTION 16950 - TESTING ELECTRICAL SYSTEMS**

### **PART 1 - GENERAL**

#### 1.1 SECTION INCLUDES

- A. This section prescribes the basic minimum requirements for field testing and inspection of electrical equipment and work.

#### 1.2 RELATED WORK SPECIFIED ELSEWHERE

- A. Refer to previous Sections which describe items of related Work. Coordinate Work prescribed by this Section with Work prescribed in previous sections.

#### 1.3 RELATED TECHICAL REQUIREMENTS

- A. Project sections.
- B. Subcontract drawings.
- C. Manufacturer's instruction manuals, drawings, and information applicable to the apparatus, equipment and systems.

#### 1.4 RELATED WORK

- A. Examine all portions of the Subcontract documents for work related to the work of this Section. Provide all work hereunder as required for the support and accommodation of related work.

### **PART 2 - CONDITIONS**

#### 2.1 GENERAL

- A. The work of this section is subject to the Fermilab Construction Subcontract Terms and Conditions and to Exhibit A, SCHEDULE AND SUPPLEMENTARY TERMS AND CONDITIONS.

#### 2.2 APPLICABLE STANDARDS

- A. The publications listed below form part of this Section. Each publication shall be the latest revision and addendum in effect on the date of subcontract award, unless noted otherwise. Except as specifically modified by the requirements specified herein or the details on the drawings, the Work included under this Section shall conform to the provisions of these publications:
  - 1. ANSI (American National Standards Institute):
    - a. ANSI/IEE 400 Guide for Making High Direct Voltage Tests on Power Cable Systems in the Field.

2. IEEE (Institute of Electrical and Electronics Engineers).
3. NEMA (National Electrical Manufacturers Association).
4. NETA (National Electrical Testing Association).

## **PART 3 - EXECUTION**

### **3.1 GENERAL**

- A. This Section provides guidelines for the inspection, testing, and checkout of the electrical systems to ensure that the electrical installation is in accordance with the design sections, drawings, and manufacturer's instructions.
- B. The listings and descriptions of the inspections, tests, and checks described herein shall not be considered as complete and all inclusive. Additional normal standard construction (and sometimes repetitive) checks and tests may be necessary throughout the course of the Work.
- C. Medium voltage cable testing shall be performed by an independent subcontractor in accordance with NETA (National Electrical Testing Association).
  1. Independent testing subcontractor will be selected and supervised by Fermilab and paid by the Subcontractor.
  2. Coordination of cable testing shall be arranged under this subcontract (cable installation subcontract) to provide Fermilab and testing subcontractor with ample time and notice. Cable installation subcontractor shall provide the Fermilab Construction Coordinator 24-hours notice of time and period available for cable testing.
  3. Cable installation subcontractor shall provide a knowledgeable workman to be present at all times during the cable testing. Workman's duties and responsibilities shall include, but not be limited to, verification of cables to be tested, removal of end boots or seals, verification of all safety precautions, keeping manholes free from water and acting as subcontractor's representative for verification of cable test results.
  4. Independent cable testing subcontractor is responsible for hi-pot testing as cables (only) as described on Form #65F1104, attached.
  5. All other testing and reporting as described herein shall be the responsibility of the cable installation subcontractor.
- D. The checks and tests shall be documented on the attached Quality Control Forms. Quality Control Forms shall be available for Fermilab review at any time during the Subcontract. Completed Quality Control Forms shall be given to the Fermilab Construction Coordinator at the conclusion of the Subcontract.
- E. Subcontractor shall be responsible for all inspection and test activities. The detail implementation plan shall be reviewed and approved by the Fermilab Construction Coordinator.

- F. Equipment or circuitry shall not be energized, de-energized, or tied-in to a system without prior review and approval of the test plan and procedure, prepared and submitted by the Subcontractor.

### 3.2 TESTING AND INSPECTION OF EQUIPMENT AND CABLE

#### A. Preparation:

1. A detailed plan and schedule shall be prepared for inspection and testing activities.
2. Manufacturer, make, model and serial numbers of the instruments used shall be recorded on the test forms.
3. Testing and checkout work shall be performed with fully qualified personnel skilled in the particular tests being conducted. This is essential for obtaining and properly evaluating data while the tests are in progress, and for ensuring that important facts and questionable data are reported.
4. The test supervisor shall ensure that testing and checkout work is conducted in a safe manner. Special safety precautions such as the following shall be utilized:
  - a. Lockout and tagout procedures.
  - b. Barricades.
  - c. De-energization or isolation of equipment before testing.
  - d. Review of procedures with safety personnel.
  - e. Erection of warning signs.
  - f. Stationing of guards and watchmen.
  - g. Maintenance of voice communications.
  - h. Personnel orientation.
  - i. Project Hazard Analysis and Job Hazard Analysis as required.
5. The test apparatus shall be of the proper voltage class and rating for the test being performed. Care shall be taken that the installation shall not be overstressed.
6. At any stage of construction and/or when electrical equipment or systems are determined to be damaged, faulty, or requiring repairs, the electrical equipment or systems shall be reported to the Fermilab Construction Coordinator. Corrective action may require prior approval.

### 3.3 INSPECTION AND TEST OF ELECTRICAL INSTALLATION

- A. Additional inspections may be carried out by Fermilab. Fermilab inspection shall

not alleviate the requirement for inspection as defined herein.

#### **PART 4 - ATTACHMENTS**

Attachment 6: Form: 65F1300:	Electrical Punch List Record
Attachment 7: Form: 65F1200:	Underground Conduit (Duct Bank) Inspection Checklist
Attachment 9: Form: 65F1202:	Aboveground Conduit Inspection Checklist
Attachment 10: Form: 65F1100:	Conduit Sealing Inspection Record
Attachment 12: Form: 65F1204:	Cable Pulling Inspection Checklist
Attachment 13: Form: 65F1101:	Insulation Resistance Test Record
Attachment 15: Form: 65F1205:	Medium and High Voltage Cable Termination Inspection Checklist
Attachment 16: Form: 65F1103:	Medium and High Voltage Cable Splice Inspection Record
Attachment 17: Form: 65F1104:	DC High Potential Test (Medium Voltage Cable) Test Record
Attachment 18: Form: 65F1105:	Ground/Earthing System (Grid or Loop Type System) Inspection Record
Attachment 21: Form: 65F1108:	Ground Continuity (Non-electrical Equipment/Structures) Test Record
Attachment 23: Form: 65F1110:	Panelboard Inspection Record
Attachment 42: Form: 65F1129:	Electric Motor Run-In Test Record



SECTION 16950  
ATTACHMENT 7  
FORM: 65F1200  
UNDERGROUND CONDUIT (DUCT BANK) INSPECTION CHECKLIST

DATE:	REV.:
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NOTE: THIS CHECKLIST SHALL BE USED DURING THE INSPECTION OF UNDERGROUND UTILITIES

- |     |   |  |
|-----|---|--|
| 1.  | Trenching checked for location, elevation and forming. Check for conflicts with other construction. |  |
| 2.  | Conduit size, type and location checked for conformance to Sections and drawings                    |  |
| 3.  | Minimum concrete coverage will be in accordance with Sections on all sides of conduits.             |  |
| 4.  | Conduit spacing, supports and tie-downs correct.  |  |
| 5.  | Stub-up dimensions and location checked.  |  |
| 6.  | Field bend radius correct in accordance with drawings/Section bends free of deformities.            |  |
| 7.  | Pipe caps on all ends   |  |
| 8.  | All conduit connections tightly made.   |  |
| 9.  | Reinforcing bars installed when specified.  |  |
| 10. | All field changes recorded on as-built drawings   |  |
| 11. | Trench or forms free of debris  |  |
| 12. | Concrete coverage adequate, spacers not left exposed.   |  |
| 13. | Concrete color in accordance with Sections.   |  |
| 14. | Stub-up concrete encasement correct.  |  |
| 15. | Backfill and compaction correct   |  |
| 16. | Conduits free of such things as stoppages and grout leakage.  |  |

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SECTION 16950  
ATTACHMENT 9  
FORM: 65F1202  
ABOVEGROUND CONDUIT INSPECTION CHECKLIST

DATE:	REV.:
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NOTE: THIS CHECKLIST SHALL BE USED DURING THE INSPECTION OF CONDUIT

1	Supports and spacing in accordance with Sections, codes & drawings	
2.	Supports adjacent to terminal fittings.	
3.	Conduits clean, stub-ups protected, open ends plugged, damage during construction repaired	
4.	Field bend radius correct in accordance with Sections and codes. Bends free of deformities.	
5.	Expansion joints as required.	
6.	Installation neat and evenly spaced	
7.	Conduit permanently and effectively grounded, unless Sections permit otherwise. Bonding jumpers installed around inspection joints.	
8.	Proper fittings installed with threads fully engaged; no wrench cuts, conduit ends have bushings and covers installed	
9.	Drains installed in accordance with Sections.	
10.	RGS, PVC or PVC-coated conduit installed when specified on drawings	
11.	Flexible conduits installed with proper bending radius and with standard fittings.	
12.	Junction boxes leveled and supported with proper hubs, locknuts and bushings installed, in accordance with drawings. Junction boxes properly identified.	
13.	Adequate number of pulling points.	

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SECTION 16950  
ATTACHMENT 12  
FORM: 65F1204  
CABLE PULLING INSPECTION CHECKLIST

DATE:	REV.:	REF. DWG.:
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NOTE: This Inspection Checklist shall be used for cable pulling in conduit and ducts.

1. Check that conduit has been swabbed-out and any standing water removed.
2. Check that number of pulling points is adequate and the number of bends between pulling points does not exceed Section or code requirements.
3. Check cable reel assignments and cutting schedules.
4. Check cable voltage rating, minimum pulling temperature and type of pulling compound.
5. Inspect cables for jacket damage.
6. Ambient temperature within manufacturer's recommended installation limits.
7. Monitor pulling tension on critical pulls and verify that maximum permitted tension not exceeded in accordance with tension data.
8. Perform DC High Potential Test (hypot) on medium and high voltage cables (rated over 2000 volts) and record on Test Record, Form 65F1104, DC High Potential Test Record (Medium Voltage Cable).
9. Bend radius of trained cable is in accordance with Sections and cable is free of kinks.
10. Installation is neat and cable lay (maintained spacing) in accordance with Sections.
11. Cables identified in accordance with Sections and drawings.
12. Cable ends sealed after cutting.
13. Manhole grounding system installed.
14. Cable neutral conductors grounded.
15. Cables firewrapped in manholes.


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SECTION 16950  
ATTACHMENT 13  
FORM: 65F1101  
INSULATION RESISTANCE TEST RECORD

DATE: \_\_\_\_\_ REV.: \_\_\_\_\_

TEST EQUIPMENT: \_\_\_\_\_

TEST VOLTAGE: \_\_\_\_\_

AMBIENT TEMPERATURE: \_\_\_\_\_ ° C \_\_\_\_\_ ° F

Panel No. Feeder No. Circuit No.	Wire Tagging	Cable- rated Voltage	Quantity	Size	From	To	Insulation Resistance (Megaohms)	Initials

Cable-rated voltage (ohms) \_\_\_\_\_

Test duration \_\_\_\_\_

Resistance for cable quality \_\_\_\_\_

Cable/wire size or amperage (megaohms) \_\_\_\_\_

Resistance when cable connected to equipment \_\_\_\_\_

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SECTION 16950  
ATTACHMENT 15  
FORM: 65F1205  
MEDIUM AND HIGH VOLTAGE CABLE TERMINATION INSPECTION CHECKLIST

DATE: _____	REV.: _____
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NOTE: This Inspection Checklist shall be used for terminations rated greater than 2000 volts. Inspection Record

CIRCUIT NO.: \_\_\_\_\_ DWG.: \_\_\_\_\_  
 KIT MANUFACTURER: \_\_\_\_\_ KIT NO.: \_\_\_\_\_

	<b>Check Item</b>
1. Cable size, type, location, installation and routing in accordance with drawings.	
2. Bend radius in accordance with specifications and cable jacket free of kinks.	
3. Cable termination supports and support spacing in accordance with drawings and specifications.	
4. Installation neat and evenly spaced.	
5. Cable free of surface damage.	
6. Termination kit/materials installed in accordance with manufacturer's instructions.	
7. Document DC High Potential Test (hypot) on Form 65.F1104, DC High Potential Test Record (Medium Voltage Cable), or obtain appropriate documentation from testing Subcontractor.	
8. Cable terminated in accordance with equipment manufacturer's instructions including torquing of bolted connections.	
9. Check phase location and marking: Left to Right, Top to Bottom, or Front to Rear, in accordance with specifications requirements. A. Acceptable _____ B. Acceptable _____ C. Acceptable _____	
10. Metallic Sheaths/Shields/Armor grounded/earthed in accordance with manufacturers recommendations.	

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SECTION 16950  
ATTACHMENT 16  
FORM: 65F1103  
MEDIUM AND HIGH VOLTAGE CABLE SPLICE INSPECTION TEST RECORD

DATE: _____	REV.: _____
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NOTE: This Inspection Record shall be used for cables rated greater than 2000 volts. INITIAL/DATE

REFERENCE DWG. _____	SPLICE NO. _____
SPLICE KIT _____	MANUFACTURER _____
KIT NO _____	KIT NO _____
CIRCUIT NO _____	_____
FROM _____	TO _____
CABLE RATED VOLTAGE _____	CABLE TYPE _____

1. Location  
Manhole Number \_\_\_\_\_
2. Splice Make-up:
  - A. Acceptable \_\_\_\_\_
  - B. Acceptable \_\_\_\_\_
  - C. Acceptable \_\_\_\_\_
  - Neutral Acceptable \_\_\_\_\_
3. Document DC High Potential Test (hypot) on Form 65F1104, DC High Potential.  
  
Test Record (Medium voltage Cable), or obtain appropriate documentation from testing Subcontractor. \_\_\_\_\_
4. Sheath grounded/earthed, as required \_\_\_\_\_
5. Field changes recorded on as-built drawings. \_\_\_\_\_
6. Splice markers installed. \_\_\_\_\_

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SECTION 16950  
 ATTACHMENT 17  
 FORM: 66F1104

DC HIGH POTENTIAL TEST (MEDIUM VOLTAGE CABLE) TEST RECORD

DATE: _____	REV.: _____
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CIRCUIT NUMBER: _____	REF DWG.: _____
CABLE SIZE: _____ (SQMM)	(MCM) FROM: _____ TO: _____
NUMBER OF CONDUCTORS: _____	NUMBER OF SPLICES: _____
CABLE LENGTH _____	MANUFACTURER: _____
INSULATION TYPE: _____	THICKNESS: _____
JACKET MATERIAL: _____	
WEATHER: _____	TEMP: _____ °C _____ ° F HUMIDITY: _____ % DATE: _____
TEST EQUIPMENT USED: _____	

NOTES:

1. The test voltage shown below shall be reached in 10 equal voltage increments.
2. After each voltage increase, the leakage current shall be allowed to stabilize during a 1 minute interval. If 1 minute intervals are insufficient to stabilize the current, the cable shall be discharged, and the test repeated with new time intervals of greater, but still equal duration
3. Record the stabilized leakage current, in microamps, at the end of each time interval.
4. Allow the voltage to remain constant at the full test voltage and record the leakage current for 5 minutes for unshielded cables and 15 minutes for shielded cables.
5. Read test equipment instruction manual prior to testing cable
6. When Project specifies the plotting of test results, attach 2ND sheet with separate plot for each phase. Note leakage current, in microamps, on "y" axis. Note step-voltage increase on "x" axis, followed by time, in minutes, for the dielectric absorption portion of the test.
7. All other phases and shields to be grounded.



Voltage Hold Time

At Each Step:

sec	Kv	Kv	Kv	Kv	Kv	Kv	Kv	Kv	Kv
∅A									
∅B									
∅C									

Time	sec	min	min	min	min	min	min	min	min	min	min	min	min	min	min	min
At Kv	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

CABLE RATED VOLTAGE

(kilovolts)

TEST VOLTAGE

(kilovolts)

\_\_\_\_\_  
Tester's Initials

\_\_\_\_\_  
Date

DISTRIBUTION

SUBCONTRACTOR/DATE

\_\_\_\_\_

SECTION 16950  
 ATTACHMENT 18  
 FORM: 65F1105  
 GROUNDING/EARTHING SYSTEM INSPECTION RECORD  
 (GRID OR LOOP-TYPE SYSTEM)

DATE:	REV.:	REF. DWG.:
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NOTE: This Inspection Checklist shall be used for installation and checking of Main Grounding/Earthing System.

1. Primary conductor is correct size and type in accordance with drawings.
2. Ground/earthing conductor burial depth and routing per drawings and Sections.
3. Thermal/compression connections checked (no cold joints or burn-outs).
4. Thermal/compression connection insulation checked.
5. Ground/earthing anode locations and installation per drawing.
6. Ground/earthing anode connections checked.
7. Location, type, size and insulation color of equipment taps per drawings and protected during construction.
8. System ground/earthing anode resistance-to-earth checked and recorded on Form 65F1106, Ground/Earthing Anode Testing Test Record (Attachment 19).
9. All field Revisions recorded on as-built drawings.


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SECTION 16950  
ATTACHMENT 21  
FORM: 65F1108  
GROUNDING CONTINUITY TEST RECORD  
(NON-ELECTRICAL EQUIPMENT/STRUCTURES)

DATE:	REV.:	REF. DWG.:
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TEST EQUIPMENT USED: \_\_\_\_\_ WEATHER: \_\_\_\_\_

**1.3**

Equipment Tag No. Or Structure	Drawing	Measured Resistance (ohms)	Initials & Date

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SUBCONTRACTOR/DATE \_\_\_\_\_

SECTION 16950  
ATTACHMENT 23  
FORM: 65F1110  
PANELBOARD INSPECTION RECORD

DATE:		REV.:	
BUILDING:	AREA/UNIT:	PANEL BOARD TAG:	

1. Receiving Operations/Inspection complete.
2. Check assembly for any missing parts.
3. Enclosure approved for area of installation.
4. Panelboard circuit schedule filled out.
5. Correct circuit breaker and location.
6. Neutral and phase conductors correctly color-coded.
7. Grounding/earthing installed and connected. Test Record, (Form 54F1109, Attachment 22) Ground Continuity Test Record (Electrical Equipment and Ground Test Bars), completed.
8. Check panel load balance.
9. Check color-coding of branch circuit conductors.
10. Clean out.
11. Check mounting and supports.
12. Fixtures and receptacles are correct type and installed as per drawings.
13. Fixtures and receptacles on correct circuit.
14. Nameplate, number of circuits and panelboard location per drawing.
15. Megger buses (including neutral). Record results on Form 65F1124 (Attachment 37), Insulation Resistance (Equipment) Test Record. Main disconnect and outgoing circuits should be open.
16. Final inspection complete. Punch items on Form 65F1300, Electrical Punch List Record, cleared


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SECTION 16950  
ATTACHMENT 42  
FORM: 65F1129  
ELECTRIC MOTOR RUN-IN TEST RECORD

DATE: MOTOR TAG NO.: REF. DWG.:	REV.: TEST EQUIPMENT:
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Notes:

1. Duration of tests to comply with Subcontract Selections.
2. Complete Form 65F1127, Electric Motor – Electrical Activities Inspection Record, prior to energizing motor.

TEST	REMARKS	INITIALS/DATE
RESISTANCE (in ohms): Bonding resistance measured from motor frame to Main ground/earth system tap.  _____		
VOLTAGE (in volts): Actual voltage measured at Motor Control Center  _____		
ROTATION CHECK: Bump motor to verify rotation. Motor shall be Uncoupled.		
NO LOAD CURRENT (in aamps): At beginning of test: _____ At end of test: _____		
TEMPERATURE OF BEARING: Check bearing for high temperature: Before start: _____ 15 minutes after start: _____ 30 minutes after start: _____ 1 hour after start: _____ 2 hours after start: _____ 3hours after start: _____		
VIBRATION: Make visual inspection during run-test. Record any unusual vibration in remarks column.		
NOISE: Record any unusual noise in remarks column.		

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**END OF SECTION 16950**