SECTION 16780 - FIBER OPTIC CONDUITS ALONG PIPELINES

City of San Diego, CWP Guidelines

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NTS: The bracketed material in this Section pertains to fiber optic cable. If pulling cable furnished by the Control Systems Provider (CSP), Westinghouse, is not the CONTRACTOR's responsibility, delete everything in square brackets.

Where fiber optic system is required, the DESIGN CONSULTANT shall show the horizontal and vertical alignment of each fiber optic conduit, and location of all fiber optic pull boxes in the Contract Drawings.

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PART 1 -- GENERAL

1.1 WORK OF THIS SECTION

A. The WORK of this Section includes providing a fiber optic conduit system [including the fiber optic cable (FOC) which will be furnished by the OWNER (FBO). FOC shall be installed only by an OWNER-approved subcontractor.]

[B. Fiber optic cable splicing will be performed by a separate Contractor under a separate contract with the OWNER. That separate Contractor will monitor installation of the fiber optic conduit system.]

1.2 RELATED SECTIONS

A. The WORK of the following Sections applies to the WORK of this Section. Other Sections of the Specifications, not referenced below, shall also apply to the extent required for proper performance of this WORK.

1. Section 02200 Earthwork

1.3 SHOP DRAWINGS AND SAMPLES

A. The following shall be submitted in compliance with Section 01300:

1. Catalog Data: Catalog data on conduit system, pull boxes, conduit fittings, conduit sealant, pull rope, identification tape, warning signs.

2. Detailed bill of materials.

3. Drawings indicating the locations of all pull boxes with station numbers.

[4. Catalog data on all testing devices proposed for use plus certifications of accuracy, calibration, and traceability to standards of the National Institute for Standards and Testing.]

[5. Cable pulling calculations for all conduit runs. Indicate on the submittal any additional pull boxes that are required, including station number and a written description of the location.]

[6. A cable pulling and splicing work plan shall be submitted a minimum of 45 days prior to the planned initiation of cable pulling. The cable pulling and splicing work plan must be approved a minimum of 15 days prior to pulling cable. Work plan shall include the following:

a. Pull tension calculations
b. Detailed description of pull operation methods for all conduit runs
c. Tools and equipment to be used for cable installation and testing
d. Physical location of equipment setup and type
e. Exact location of splice points
f. Safety and manual assist cable pulling operations
g. Detailed schedule for pulling and testing cables]

[7. Information on at least one successfully performing fiber optic cable installation of comparable size and complexity installed in the recent past with name, address, and telephone number of facility owner, name of project and completion date, and type of conduit system and length of cable pulled.]

[8. The name and qualifications of the supervisory personnel that will be directly responsible for the installation of the conduit system.]

[1.4 QUALIFICATIONS, APPROVAL AND DOCUMENTATION OF FOC PULLING SUBCONTRACTORS

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NTS: The DESIGN CONSULTANT must document for the project file the rational basis for recommending pre-approval of any subcontractors to be listed below. The criteria used must be the same as listed in paragraph 1.4 B. The DESIGN CONSULTANAT shall submit the recommendation for pre-approval to the City before this Section can be advertised for bids.

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A. **Pre-Approved FOC Pulling Subcontractors**

[1.]
[2.]
[3. or equal]

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NTS: In paragraph "B" below, define the terms "comparable size and complexity" for the fiber optic cable. Requiring experience of more than one successful project requires sound justification and prior written approval from the City's Project Manager.

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B. **Qualifications of FOC Pulling Subcontractor:** Firm with at least one successful installation of cable systems of size and complexity comparable to this project. A comparable project is [ ].

C. **Approval**

1. Unless bidders select a pre-approved cable pulling subcontractor, bidders shall be prepared to submit the name and documented qualifications of the subcontractor proposed for pulling the cable. The OWNER will review and approve the proposed selection by the apparent low bidder. In the case where the OWNER does not approve the proposed selection, the apparent low bidder shall select one of the pre-approved subcontractors listed above at no increase in the bid price(s) or the Contract Price.

2. Documentation to be submitted by the apparent low bidder

   a. Documentation indicating that the proposed subcontractor has at least one successful installation of cable of comparable size and complexity.

   b. The name and address of the owner and location and completion date of each project listed above.

   c. A copy of a current Dunn and Bradstreet report, or equivalent, indicating the financial state of the proposed subcontractor firm.]

PART 2 -- PRODUCTS

2.1 MATERIALS

A. **Conduit:** Four inch diameter PVC conduit, stiffness of DB-60, in accordance with ASTM F 512-Smooth-Wall Poly(Vinyl Chloride)(PVC) Conduit and Fittings for Underground Installation. This conduit is non-pressure PVC pipe, but it has adequate stiffness for direct burial usage without encasement in concrete.

B. **Pull Boxes:** Pull boxes shall be approximately 32 inches wide by 49-5/8 inches long by 36 inches deep, designed for H-20 traffic loading unless otherwise indicated. Covers shall be galvanized steel with the words "Fiber Optics" in raised letters on the upper surface. Covers shall have locking devices and form a watertight seal to prevent surface water from entering. Knockouts in the sidewalls shall permit underground conduit side entry and exit. Provide **George Ingraham, Vikamatic** or equal.

C. **Conduit Sealant: Semco** duct sealing compound or equal.

D. **Identification Tape:** A 6 inch wide magnetically detectable warning tape with orange protective polyethylene jacket resistant to alkalies, acids, and other destructive elements shall be installed beside the warning tape for the pipeline along the entire length of the conduit route. The polyethylene tape shall be continuously imprinted "CAUTION-FIBER OPTIC CABLE". The warning tape shall be **Teletrace by George Ingraham, Vikamatic**, or equal.

E. **Pull Rope:** Low friction, polyethylene jacketed polypropylene rope with 1800 psi tensile strength. Provide **Vikamatic "Fiber Glide"** or equal.

[F. **Fiber Optic Cable:** The following specifications are representative of the FOC, but due to variations between cable manufacturing runs and manufacturers, the OWNER anticipates that the properties of the FOC may vary by as much as 25%. [The CONTRACTOR shall include in the bid all costs associated with the installation of FOC.]

1. Outdoor, buried cable rated
2. Tight buffered
3. Single mode suitable for FDDI
4. 8.3 microns core diameter
5. 125 microns cladding diameter
6. 500 microns coating diameter
7. 900 microns tight buffer diameter
8. 24 optical glass fibers encased in primary polymer buffer
9. Primary buffer encased in a secondary hard elastomeric polymer buffer
10. Weight of 60 kg/km
11. Minimum bend radius during installation = 20 times outside diameter
12. Minimum bend radius under long-term tensile load = 10 times outside diameter
13. Outer diameter 8.0 mm

14. Tensile pull strength rating of 600 lbs.]

[G. The FOC will be shipped on reels which have approximately 4,000 to 6,000 feet of cable without splice. [FOC reels will be labeled to identify CONTRACTOR, contract number, cable descriptions, reel number, and the start and end footage markings.]]

PART 3 -- EXECUTION

3.1 CONDUIT INSTALLATION

A. Conduits shall be installed on one side of the trench, at least 2 inches and not more than 12 inches from the trench wall, at a depth of 3 to 4 feet below grade along the entire pipeline route. The conduit shall not cross over the pipe.

B. Conduits shall clear concrete structures and vaults associated with the pipeline by a minimum of one foot.

C. The conduit shall gradually and smoothly slope up to the elevation of the pull box entrance. Use of manufactured bends shall be limited to an absolute minimum. Factory bends, if required, shall be no more than 22-1/2 degrees.

D. Conduit sections shall be joined in accordance with the Manufacturers' recommendations. All joints shall be watertight.

E. CONTRACTOR shall install pull rope in the conduit.

F. Conduits entering pull boxes shall be capped or sealed watertight.

G. Bedding and backfill shall be select sand in accordance with Section 02200, placed at least 4 inches thick below and above the conduit, compacted to at least 90 percent maximum density.

H. Conduit shall be installed in the annular space between the carrier pipe and the casing or tunnel liner for all two-pass tunnel or jack and bore sections of the pipeline alignment.

3.2 PULL BOXES

A. **Field Location of Pull Boxes**

1. The drawings diagrammatically indicate the desired location of pull boxes, conduit runs and other items. Exact locations shall be determined by the CONTRACTOR based on physical size and arrangement of equipment, finished elevations, calculated cable pulling tensions, field obstructions, and the criteria below. Locations shown on the drawings should be followed as closely as possible, however, pull boxes shall be located according to the following criteria:

   a. At no point shall the cable pulling tension exceed 600 pounds. If cable pulling tension is calculated to exceed 600 pounds, additional pull boxes shall be provided at no extra cost to the OWNER.

   b. The maximum distance between any two pull boxes shall not exceed 1,200 feet.

   c. Within the 1,200-feet distance, the CONTRACTOR shall install pull boxes at locations wherever the cumulative change of direction of the conduit exceeds 180 degrees.

   d. The minimum bending radius for conduit shall be 3 feet.

e. A pull box shall be installed on one side of a tunneled crossing. However, for any crossing which requires more than 180 degrees of conduit bends to account for elevation differences or route adjustments, a pull box shall be installed on both sides of the crossing.

f. Pull boxes shall be installed a minimum of 12 inches from all structures.

B. **Construction**

1. The CONTRACTOR shall install the pull box covers so that the top of the cover is flush with the restored pavement. Pull boxes installed in soil areas shall be installed so that the top of the cover is at least one inch but not more than 4 inches above the final grade level of the restored surface to prevent accumulation of dirt, silt and debris on the top of the hand hole cover.

2. CONTRACTOR shall perform conduit integrity tests for each section between the pull boxes after backfilling and compaction using the test and procedures described in this Section. These tests shall be performed prior to installation of the pull rope.

3. Pull box conduit entries shall be sealed with mortar to prevent the intrusion of water and debris into the pull boxes.

4. Pull boxes shall be installed on a compacted level foundation consisting of 4 inches of granular material complying with Section 02200.

5. Backfilling around pull boxes shall not be done until mortar sealant has thoroughly set.

6. Compaction around pull boxes and associated details shall be performed in accordance with Section 02200.

7. Upon final acceptance of the conduit system all pull boxes shall be free of debris and water, and be ready for cable installation.

3.3 MODIFICATIONS

A. All dimensions and exact locations of underground substructures shall be field verified. Minor changes in locations of pull boxes which result in no additional costs for material or labor shall be made at no additional cost to the OWNER. However, the CONTRACTOR shall prepare proposals consisting of detailed material lists, cost estimates, and schedules for rerouting the conduit around existing unforeseen underground utilities and structures which result in additional cost. The CONSTRUCTION MANAGER will consider the proposals in accordance with the change provisions of the General Conditions.

B. The CONTRACTOR shall consider the following when preparing proposals:

1. Manufactured bends shall be minimized

2. Required bends shall be less than 22-1/2 degrees

3. Clearances between conduits and other structures shall be:

Structures	Minimum Separations
Power or other foreign conduit	12 inches
Pipe for gas, oil, water, sewage	6 inches when crossing: 12 inches when parallel

[3.4 CABLE MARKER SIGNS

A. The CONTRACTOR shall also install marker signs for fiber optic cable on all marker posts for the pipeline as indicated.]

3.5 CONDUIT SYSTEM CLEANING AND TESTING

A. Following the backfill placement and compaction, all conduits shall be cleared of loose material by brush and compressed air.

B. Conduit shall be tested for leakage by air testing at 5 psi, maintaining the pressure for one hour without showing any leakage.

C. Following the leakage test, a test mandrel 3/8 inch smaller than the inside diameter shall be passed through all conduits to detect alignment and deformation problems. Mandrel shall be passed in both directions.

D. Cleaning and testing of the conduit shall be performed by the CONTRACTOR and witnessed by the CONSTRUCTION MANAGER. The cleaning and testing operation shall be conducted for each conduit section between adjacent pull boxes, a section at a time, for the entire route. The results of tests shall be documented by the CONTRACTOR and signed by the CONSTRUCTION MANAGER and the CONTRACTOR.

E. The CONTRACTOR shall provide a five-day advance notice of the schedule and location of test to the CONSTRUCTION MANAGER.

F. The CONTRACTOR shall remove and replace conduit which fails either test and shall repeat the test.

[3.6 FIBER OPTIC CABLE INSTALLATION REQUIREMENTS

A. FOC shall be installed in continuous lengths without intermediate splices. The cable installation personnel shall be experienced with specific knowledge of the cable manufacturer's recommended procedures, and as a minimum shall conduct their work to conform to the following:

1. The FOC's strength elements shall be properly attached to a 600 lb breakaway swivel using Kellums pulling grips.

2. Cable tensile limits and tension monitoring devices shall not exceed cable pull tension and bend limits.

3. All conduits shall be constantly lubricated during the pulling procedures.

4. Each pull box shall contain extra FOC for pull box slack.

B. The CONTRACTOR shall conform with the cable manufacturer's specifications, practices, and the following requirements:

1. When power equipment is used to install fiber optic cables, low speeds shall be used so that a rate of 30 meters per minute is not exceeded. The tensile and bending limitation for fiber optic cables shall not be exceeded under any circumstances. Large diameter wheels, pulling sheaves, and cable guides shall be used to maintain the specified bending radius. Tension monitoring shall be accomplished using commercial dynamometers or load-cell instruments.

2. All conduit shall be cleaned and tested prior to installation.

3. All conduits shall have a lubricant applied at each conduit ingress and egress location and during the pull operation. Lubricant shall be **Polywater Type 5**, or equal.

4. FOC shall be installed using a hydraulic capstan or winch equipped with a recording running line dynamoter graph which measures and records pulling tensions. All equipment shall be designed to prevent a preset pulling tension from being exceeded. The pulling tension setpoint shall be determined by the FOC manufacturer. If during the pulling operation excessive tension is detected, all operations shall cease and the CONSTRUCTION MANAGER shall be notified.

5. All pulls shall be documented by a graph which is annotated with the following information:

   a. Reel number
   b. Station from and station to
   c. Date and time
   d. Explanations of abnormalities in readings or interruptions
   e. Sign-off by CONTRACTOR and CONSTRUCTION MANAGER

6. Under no conditions shall the FOC be left exposed or unattended.

C. All FOC splicing will be performed by others.

D. After the cables are installed and spliced, they shall be racked and spare conduits sealed. A minimum of 30 feet of FOC shall be stored at each end of one splice. Racking shall conform to the following:

1. Cables shall be loosely secured in racked position with **Ty-Raps** or equal.

2. Imprinted plastic coated cloth identification/warning tags shall be securely attached to the cables in at least two locations in each handhole. Tags shall be by **Brady** or **Thomas & Betts**.

3. All coiled cable shall be suitably protected to prevent damage to the cable and fibers. Racking shall include securing cables to brackets and racking hardware that extend from the sidewalls of the handhole.

4. When all cables at each handhole are securely racked, unused conduits and void areas around conduit containing cables shall be sealed using the Semco or equal material.]

[3.7 FOC TESTING

A. **General:** The CONTRACTOR shall perform pre-installation and post-installation FOC tests. The CONSTRUCTION MANAGER shall be notified a minimum of 10 days in advance so that these tests are witnessed. All test equipment shall be traceable to NIST standards.

B. **Test equipment:** The CONTRACTOR shall use the following to perform pre-installation and post-installation FOC tests:

1. Optical time domain reflectometer (OTDR). The OTDR shall be laser precision, **ALT Inc MODEL 5200 LRFL**, or equal.

C. **Pre-installation tests**

1. The purpose of these tests is to perform acceptance tests on the cable prior to installation to verify that the cable conforms to the manufacturer's specifications, and is free of defects, breaks and damages by transportation and manufacturing processes. The tests shall certify continuity and attenuation or loss for each fiber on each reel and document results

of physical inspections to identify any cable and reel damage conditions and any deviations from the manufacturer's specifications.

2. The CONTRACTOR shall perform tests on all reels of cable. The CONSTRUCTION MANAGER shall be notified a minimum of 15 days prior to any test.

3. The CONTRACTOR shall document each test and submit the report to the CONSTRUCTION MANAGER for review. Documentation shall consist of both hard copy and 3-1/2 inch electronic disk complete with all application software.

4. Cable shall not be installed until the CONSTRUCTION MANAGER has reviewed the test report.

D. **Post-installation tests:** After FOC has been installed but prior to splicing, the following tests shall be performed:

1. A recording OTDR shall be utilized to test for end-to-end continuity and attenuation of each optical fiber. The OTDR shall be equipped with a 1300 nm and 1550 nm light source for the single mode fiber (SMF). The OTDR shall have an X-Y plotter to provide a hard copy record of each trace of each fiber. The OTDR shall be equipped with sufficient internal masking to allow the entire cable section to be tested. This may be achieved by using an optical fiber pigtail of 30 feet or more to display the required cable section.

2. The OTDR shall be calibrated for the correct index of refraction to provide proper length measurement for the known length of reference fiber.

3. A transmission test shall be performed with the use of a 1300 and 1550 nm stabilized light sources and 1300 nm/1550 nm power meters for SMF. This test shall be conducted in both directions on each fiber of each cable.

4. Hard and electronic copy of test documentation shall be submitted to the CONSTRUCTION MANAGER. The CONTRACTOR shall compare the pre-installation test results to the post-installation results. If a deviation of greater than one db occurs, the CONSTRUCTION MANAGER shall be notified in writing by the CONTRACTOR, and the cable shall be removed and replaced at no additional cost to the OWNER.]

5. Upon completion of the previous tests and all splicing operations, all FOC coils shall be secured with ends capped to prevent intrusion of dirt and water.

3.8 RECORD DRAWINGS

A. In compliance with Section 01700, the CONTRACTOR shall upon completing the construcition of the fiber optic system, submit to the CITY Record Drawings showing the following:

1. Horizontal alignment of fiber optic conduit

2. Vertical alignment of fiber optic conduit

3. Location of all pull boxes using Station Number, and the exact Northing and Easting of each pull box using the North American Datum (NAD) 83 coordinate system.

** END OF SECTION **