## Table of Contents

### SECTION 17
Overhead Contact Systems

<table>
<thead>
<tr>
<th>Section No.</th>
<th>Title</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Summary of work</td>
<td>4</td>
</tr>
<tr>
<td>01300</td>
<td>Contract Data Requirements List</td>
<td>8</td>
</tr>
<tr>
<td>01330</td>
<td>Submittals</td>
<td>8</td>
</tr>
<tr>
<td>17301</td>
<td>General Requirements</td>
<td>7</td>
</tr>
<tr>
<td>17303</td>
<td>Interface Requirements</td>
<td>4</td>
</tr>
<tr>
<td>17305</td>
<td>Design and Installation Requirements</td>
<td>12</td>
</tr>
<tr>
<td>17307</td>
<td>Basic Electrical Materials &amp; Methods</td>
<td>8</td>
</tr>
<tr>
<td>17310</td>
<td>Overhead Contact System Tubular Poles</td>
<td>8</td>
</tr>
<tr>
<td>17311</td>
<td>Pole and Down Guy Anchor Foundations</td>
<td>17</td>
</tr>
<tr>
<td>17312</td>
<td>Poles Powder Coating</td>
<td>2</td>
</tr>
<tr>
<td>17313</td>
<td>Wide Flange Metal Poles</td>
<td>8</td>
</tr>
<tr>
<td>17314</td>
<td>Pole Painting</td>
<td>5</td>
</tr>
<tr>
<td>17315</td>
<td>Signage</td>
<td>2</td>
</tr>
<tr>
<td>17316</td>
<td>Grounding and Bonding of Assemblies</td>
<td>5</td>
</tr>
<tr>
<td>17319</td>
<td>Supporting Devices</td>
<td>5</td>
</tr>
<tr>
<td>17321</td>
<td>Galvanized Steel Wire &amp; Wire Rope</td>
<td>3</td>
</tr>
</tbody>
</table>
## OVERHEAD CONTACT SYSTEM

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>17323</td>
<td>Stainless Steel Wire Rope, Strand and Rod</td>
<td>4</td>
</tr>
<tr>
<td>17325</td>
<td>Surge Arresters</td>
<td>2</td>
</tr>
<tr>
<td>17327</td>
<td>Insulators</td>
<td>8</td>
</tr>
<tr>
<td>17329</td>
<td>Section Insulators</td>
<td>5</td>
</tr>
<tr>
<td>17331</td>
<td>Tensioning Devices</td>
<td>5</td>
</tr>
<tr>
<td>17333</td>
<td>Fittings and Hardware</td>
<td>7</td>
</tr>
<tr>
<td>17335</td>
<td>Pole Mounted Disconnect Switches</td>
<td>4</td>
</tr>
<tr>
<td>17341</td>
<td>Uninsulated Conductors &amp; Cables</td>
<td>5</td>
</tr>
<tr>
<td>17351</td>
<td>Testing</td>
<td>8</td>
</tr>
<tr>
<td>17352</td>
<td>Insulated Feeder Cable</td>
<td>6</td>
</tr>
<tr>
<td>17361</td>
<td>Special Tools</td>
<td>4</td>
</tr>
<tr>
<td>17363</td>
<td>Manuals and Training</td>
<td>6</td>
</tr>
<tr>
<td>17365</td>
<td>Spare Parts</td>
<td>3</td>
</tr>
</tbody>
</table>

Appendix G – List of Desired Control and Indication Points | 5
PART I - GENERAL

1.1 SUMMARY

A. Description:

1. This Section describes general requirements associated with the design, procurement of materials, manufacture, fabrication, installation, construction, testing services, training, appurtenances and incidentals necessary to complete the Overhead Contact System work in accordance with the Contract requirements and as specified in other pertinent sections of the Specifications.

2. The Facility Provider shall through a FP-Related Entity the design and construction of four Light Rail Transit ("LRT") Corridors (East End Corridor, North Corridor, Southeast Corridor and Uptown Corridor), the Intermodal Terminal Facility, the Main Street LRT Extension and the Project Maintenance facilities, using the project delivery approach described in the Hybrid Delivery System Act, Texas Transportation Code, Chapter 451, Subchapter Q, Section 451.801 through 451.812 (the "Enabling Legislation"). The Facility Provider shall be responsible for design, construction of civil works and systems, furnishing and installation of equipment and vehicles, and or through a related entity, may be responsible for the long-term Operations and Maintenance ("O&M") of the Project.

3. As part of this contract, a new Overhead Contact System (OCS) will be installed over all new tracks, and crossovers and the tail track.

   a. Provide and install a complete OCS for the new double track and single track routes including tail and turnout tracks.

   b. Provide and install OCS for the crossovers at new interlockings.
c. Provide and install OCS for the new storage tracks at all Yard/Shop Facility’s as shown on Contract Drawings.

d. Provide and install OCS sectionalizing equipment at new interlockings, existing substation locations and nineteen (21) new substation locations.

e. Provide and install positive feeder cables from substations to the OCS system at all feeder poles located at/adjacent to the tracks at all new substations and where required at existing substations.

f. Provide and install negative return cables from the negative bus bar in the new substations to the impedance bonds at the tracks.

g. Provide Operation and Maintenance manuals, As-Built Drawings, Special Tools, Mandatory Spare Parts, Recommended Additional Spare Parts and Training of HRT personnel.

h. Provide all work (and support), fully installed, adjusted, tested and commissioned in place in accordance with HRT requirements and as shown on the Contract documents.

B. Related Sections:

1. 17303 – Interface Requirements
2. 17305 – Design and Installation Requirements

1.2 REFERENCES

None

1.3 DESIGN

A. OCS Distribution System:
1. The OCS system for the new work is to be primarily of the simple 2-wire style, comprising one 500 kcmil stranded hard-drawn copper messenger wire and one 350 kcmil hard-drawn solid copper contact wire either low profile or standard profile. The exceptions to this 2-wire system are in the Yard & Shop Facilities and in the intermodal area where the OCS will be direct support single contact (trolley) wire as shown on the drawings.

2. For the new work, the OCS systems shall consist of the following styles and tensions, utilized at locations shown on the drawings:

   - Simple Catenary Auto Tension (SCAT) – 5,000 lbs tension (messenger) and 3,000 lbs tension (contact) at 70°F.

   - Single Wire Fixed Tension (SWFT) – 2000 lbs tension at 70°F.

3. The OCS is to be automatically tensioned (AT), using balance weight stacks, so that constant tension is maintained throughout the specified climatic temperature range of 30°F to 110°F.

B. The OCS Designer shall provide final design services for the Overhead Contact System that shall include, but not be limited to:

1. All mounting and line hardware with insulation (both temporary and permanent);

2. All OCS system support and registration assemblies such as cantilevers, head-spans or cross-spans, wire pull-offs, and backbone arrangements;

3. Hanger length calculations and allocations;

4. Assist with developing integrated OCS construction staging plans with all necessary traction power outages coordinated with HRT and chronologically identified.

C. The OCS Installer shall incorporate into the designs the guidelines and standards
shown in the OCS technical sheets, arrangement drawings and assembly drawings contained in the Contract Drawings as well as the pertinent design criteria provisions listed in the latest edition of the HRT Light Rail Design Criteria. See Specification Section 17305, paragraph 1.3 for a detailed description of the design submittals that the OCS Installer/Supplier is required to submit to the Engineer/HRT for review/approval.

D. The OCS electrification hardware, being all the material from the pole face out to, but excluding the conductors, shall primarily be supplied by one supplier. The OCS supplier shall be an experienced manufacturer of a major portion of the OCS hardware. Typical experienced OCS hardware manufacturers are IMPulse OEG, Dossert, Siemens, Kummler & Matter, ADtranz, and others.

E. The OCS Supplier shall be responsible for the complete engineering form, fit, and function of all equipment, components, and assemblies supplied for the OCS system. Detailed shop drawings shall be prepared for review and approval to identify the form and fit of the OCS materials. The OCS supplier shall have not less than five (5) years experience in the manufacture of performance-proven OCS hardware used on light rail systems in the United States.

F. The OCS Installer shall furnish and install OCS poles as shown on the Design Drawings. Detailed shop drawings shall be prepared for review and approval for all pole and foundation types, including all interface items such as joint-use pole brackets and attachments, if any.

G. The OCS Contractor shall be responsible for all engineering and design work for any temporary OCS system arrangements necessary to provide continued, uninterrupted use of the light rail system. Temporary components shall include, but not be limited to: poles, foundations, guy anchors, insulators, feeder/jumper cables, grounding, terminations, and rigging necessary to maintain an operable overhead contact system.

H. ENVIRONMENT: The overhead contact system equipment shall be capable of operating satisfactorily in an environment as follows:

   Elevation: 0 to 200 feet.
   Humidity: 20 to 100 percent.
   Precipitation: 10 inches maximum 24-hour.
Ambient Temperature:

High: 110º Fahrenheit.
Low: 0º Fahrenheit.
Yearly Average: 70º Fahrenheit.

**Design Climatic Conditions:**

a. Operating Conditions: The OCS design shall consider the following combination of conditions under which the system must remain operational:
   - A wind speed of 55 mph together with a conductor temperature of 125º F
   - A wind speed of 40 mph at 30 degrees F and ¼” of radial ice in the wires
   - A wind speed of 0 mph at 0º F with no ice
b. Non–operating conditions: The OCS system will be designed to be structurally stable at wind speeds of 90 mph
c. Seismic Withstand Criteria – Zone 0 in accordance with IBC recommendations

**1.4 CONSTRUCTION**

A. Furnish and install OCS support systems including cantilevers, head-span supports, and wire pull off supports on required poles.

B. Furnish, string, tension and insulate messenger and contact wires, including fabrication and erection of hangers and power feeder jumpers. Re-align or remove existing OCS wiring and associated hardware as shown on drawings.

C. Furnish and install balance weight anchor assemblies and mid-point anchors, including tensioning and insulation.

D. Furnish and install fixed termination anchor assemblies including tension reduction anchors, tensioning and insulation.

E. Connect substation positive and negative feeder cables at all new feeder pole and negative return locations.

F. Furnish and install OCS disconnect switches and associated feeders and ground mats (if allocated).

G. Furnish and install mechanical section insulators.

H. Furnish and install OCS pole identification signs.
I. Furnish and install lightning arresters, with associated grounding.
J. Furnish mandatory and recommended additional spare parts.
K. Furnish and install all necessary temporary material including poles, guys, insulators, feeder/jumper cables, splices, fittings, terminations and miscellaneous items required to enable the OCS system to be constructed in a manner consistent with civil work sequences and the vehicle testing schedule.

1. The temporary work should incorporate all requirements necessary to construct the OCS in various stages and be coordinated with civil work
L. Remove all existing OCS wire, structures, foundations, and underground positive feeders and negative return cables as indicated on the drawings
M. The temporary work should incorporate all requirements necessary to construct the OCS in various stages and be coordinated with civil work.
N. Remove all existing OCS wire, structures, foundations and underground negative & positive feeder cables as indicated on the drawings.
O. Demolish impacted OCS pole foundations (where indicated on the Contract Drawings) to a depth of at least 3 ft. below finish grade.
P. Field Testing:
   1. The Contractor shall prepare and obtain approval for the test plans and procedures as set forth in these Specifications prior to starting field testing.
   2. The Contractor shall perform all tests necessary to ensure that the overhead contact system equipment performs according to these Specifications.
Q. Provide OCS training and related training materials for HRT operating and maintenance personnel.
R. Provide OCS maintenance support during integrated and pre-revenue service testing.

1.5 CONTRACTOR SUPPORT DURING INTEGRATED TESTING AND PRE-REVENUE SERVICE

A. The OCS Installer shall provide sufficient personnel and equipment to support HRT’s Integrated Testing Program and Pre-Revenue Service operations.
B. Integrated Testing is the testing of the Light Rail Vehicle and the designed functioning of traction power substations and overhead contact system in operating and emergency simulation modes. Certain tests will be developed to analyze the performance of the overhead contact system under varying conditions.
C. The Contractor shall support these tests and maintain the overhead contact system
at full performance.

D. In the event of any malfunctions to the overhead contact system, the OCS Installer and Contractor shall quickly identify the problem and repair and replace necessary items of equipment.

E. Pre-Revenue Service operations are the LRT training runs of HRT’s Operations and Maintenance personnel. All types of operational and emergency situations will be simulated. The Contractor shall support these tests and maintain the overhead contact system at full performance. The Contractor shall provide up to four-hundred (400) man-hours plus supervision of OCS support to the Facility Provider during the pre-revenue phases, as directed by HRT.

### 1.6 NOMENCLATURE

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAR</td>
<td>Association of American Railroads</td>
</tr>
<tr>
<td>AC</td>
<td>Alternating Current</td>
</tr>
<tr>
<td>Amp or A</td>
<td>Ampere</td>
</tr>
<tr>
<td>Assy</td>
<td>Assembly</td>
</tr>
<tr>
<td>A.T.</td>
<td>Auto-Tension</td>
</tr>
<tr>
<td>AWG</td>
<td>American Wire Gauge</td>
</tr>
<tr>
<td>BIL</td>
<td>Basic Insulation Level</td>
</tr>
<tr>
<td>CAT</td>
<td>Catenary</td>
</tr>
<tr>
<td>C</td>
<td>Celsius</td>
</tr>
<tr>
<td>CDR</td>
<td>Critical Design Review</td>
</tr>
<tr>
<td>CDRL</td>
<td>Contract Data Requirements List</td>
</tr>
<tr>
<td>DEG</td>
<td>Degree</td>
</tr>
<tr>
<td>DC</td>
<td>Direct Current</td>
</tr>
<tr>
<td>EA</td>
<td>Each</td>
</tr>
<tr>
<td>F</td>
<td>Fahrenheit</td>
</tr>
<tr>
<td>FDR</td>
<td>Feeder</td>
</tr>
<tr>
<td>FRA</td>
<td>Federal Railroad Administration</td>
</tr>
<tr>
<td>FS</td>
<td>Federal Specifications</td>
</tr>
<tr>
<td>FT</td>
<td>Feet</td>
</tr>
<tr>
<td>F.T.</td>
<td>Fixed Termination</td>
</tr>
<tr>
<td>GALV</td>
<td>Galvanized</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Definition</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>GRS</td>
<td>Galvanized Rigid Steel</td>
</tr>
<tr>
<td>H.D.</td>
<td>Hard Drawn</td>
</tr>
<tr>
<td>HZ</td>
<td>Hertz</td>
</tr>
<tr>
<td>IN</td>
<td>Inch</td>
</tr>
<tr>
<td>KCMIL</td>
<td>Thousand Circular Mils</td>
</tr>
<tr>
<td>KJ</td>
<td>Kilojoule</td>
</tr>
<tr>
<td>KV</td>
<td>Kilovolt</td>
</tr>
<tr>
<td>KVA</td>
<td>Kilovolt-Amp</td>
</tr>
<tr>
<td>LB</td>
<td>Pound</td>
</tr>
<tr>
<td>LF</td>
<td>Linear Feet</td>
</tr>
<tr>
<td>LS</td>
<td>Lump Sum</td>
</tr>
<tr>
<td>MA</td>
<td>Milliampere</td>
</tr>
<tr>
<td>MCM</td>
<td>Thousand Circular Mils</td>
</tr>
<tr>
<td>MESS</td>
<td>Messenger</td>
</tr>
<tr>
<td>MNHR</td>
<td>Man-hour</td>
</tr>
<tr>
<td>MO</td>
<td>Month</td>
</tr>
<tr>
<td>NEC</td>
<td>National Electrical Code</td>
</tr>
<tr>
<td>NEMA</td>
<td>National Electrical Manufacturers Association</td>
</tr>
<tr>
<td>NESC</td>
<td>National Electrical Safety Code</td>
</tr>
<tr>
<td>NTP</td>
<td>Notice To Proceed</td>
</tr>
<tr>
<td>NIC</td>
<td>Not In Contract</td>
</tr>
<tr>
<td>OCS</td>
<td>Overhead Contact System</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Operation &amp; Maintenance</td>
</tr>
<tr>
<td>PB</td>
<td>Pushbutton</td>
</tr>
<tr>
<td>PDR</td>
<td>Preliminary Design Review</td>
</tr>
<tr>
<td>PSI</td>
<td>Pounds per Square Inch</td>
</tr>
<tr>
<td>PVC</td>
<td>Polyvinyl Chloride</td>
</tr>
<tr>
<td>QTY</td>
<td>Quantity</td>
</tr>
<tr>
<td>ROW</td>
<td>Right Of Way</td>
</tr>
<tr>
<td>RMS</td>
<td>Root Mean Square</td>
</tr>
<tr>
<td>R,S&amp;I</td>
<td>Rules, Standards and Instructions</td>
</tr>
<tr>
<td>SEC</td>
<td>Seconds</td>
</tr>
</tbody>
</table>
SECTION 17301 – GENERAL REQUIREMENTS

STA  Station, Stationing
SUB  Substation
TBD  To Be Determined
TPSS  Traction Power Substation
UL  Underwriters Laboratory
V  Volt

PART II - PRODUCTS

NOT USED

PART III - EXECUTION

NOT USED

END OF SECTION
**SECTION 17303 INTERFACE REQUIREMENTS**

**SECTION 17303**

**INTERFACE REQUIREMENTS**

**PART I - GENERAL**

1.1 **SUMMARY**

A. Description:
   1. This Section describes the various interfaces between Contractor work and work performed by others.

B. Related Sections:
   1. 17311 - Pole and Down Guy Anchor Foundations

C. Related Disciplines
   1. Traction Electrification Substations
   2. Signals
   3. Communications

1.2 **REFERENCES**

None

1.3 **QUALITY ASSURANCE**

A. Comply with the requirements of the Project Quality Plan.

1.4 **SUBMITTALS**

A. Unless otherwise specified, all submittals shall be in accordance with the Project Quality Plan.

1.5 **BASIC INTERFACES**

A. Environment:
   1. The OCS materials and equipment shall be capable of being operated, stored and maintained without impairment resulting from the impact of the environment of the Houston Texas area throughout the range of worst-case conditions specified in Section 17301.
   2. The Contractor is reminded that a portion of the work under this Contract is to be performed on, and directly adjacent to, the existing Light Rail System. The Houston Metro Light Rail normal operating hours are as published on...
3. All work interfacing with the existing Houston Metro Light Rail System shall be scheduled with the approval of Houston Metro’s Operations Department to minimize disruption of revenue train service. Special Event service schedules may include decreased headway and stacked train, first in - first out, local service, express service and operating hours longer or shorter than those listed in the Houston Metro referenced document.

B. Administration Interface:

1. The Contractor must conduct all work on the light rail system in full accord with Houston Metro’s “Construction Safety Program Manual” which is included in the RFP document. Any conflicts between this Section and the Construction Safety Program Manual shall be governed by the latter.

2. The Contractor will be permitted access to operating portions of the system on a pre-arranged basis. Access requests shall be submitted in writing, with at least seven (7) days notice, to Houston Metro.
   a. Access requirements will be provided by Houston Metro. These requirements will include scheduling, work staging, construction interfacing and the environment under which the work will be accomplished.
   b. The Contractor shall attend weekly meetings with Houston Metro and shall describe his proposed work plan for the next two weeks. These meetings will be used to effect coordination and to resolve issues.

3. Any installation or testing which affects existing light rail must be done during the hours as specified by Houston Metro and must be completed in sufficient time to allow for normal light rail service. It is the Contractor's responsibility to supply sufficient, competent employees and reserves to assure restoration of scheduled service within the allotted time. The Contractor must furnish all equipment such as, but not limited to, flags, safety vests, flares, phones, and radios, in accordance with all Houston Metro safety and access requirements.

4. Any work crew interfacing with the existing Houston Metro Light Rail System operations must be supervised by a Contractor’s employee(s) who has attended and been certified at the Houston Metro Track Access Course. The Contractor shall coordinate with Houston Metro for times, dates and locations to attend this class.

5. Work which does not affect train operations may be performed, with the authorization of Houston Metro, during Light Rail operation hours.
Orders/Bulletins, as required, will be issued by Houston Metro. The Contractor will furnish such qualified flagmen, watchmen or other employees as may be deemed necessary for safe and continuous operations at no additional cost. Detailed plans of the Contractor's procedures, including an itemized time schedule and breakdown of the labor force shall be submitted to Houston Metro at least ten (10) working days prior to implementation. Houston Metro reserves the right to determine the number of qualified flagmen necessary, based on the submitted plans.

6. Houston Metro will furnish light rail transit vehicles and vehicle operators, as appropriate, for the OCS System Integration Tests and System Demonstration Test as specified in Section 17351.

7. Lighting and electric power, where not specifically provided by others, shall be provided by the Contractor.

C. Operating Rail Line Interface (CDRL):

1. The Contractor shall submit an installation and cut-over sequence plan for all areas of construction which affect existing Houston Metro Light Rail operations. The Contractor is cautioned that the OCS work must be carefully coordinated with the associated civil, track and signaling work. The Contractor will be required to coordinate his work and cut-over schedules with all involved sub-contractors. The installation and cut-over plans shall be submitted to Houston Metro (30) days prior to commencing any field installation work, and shall include, at a minimum, the following:

   a. Narrative descriptions and schematics for temporary or interim work, methods and materials.

   b. Descriptions for the implementation and sequencing of tests as specified in Section 17351.

   c. Installation methods and sequencing implementation.

   d. Narrative descriptions and schematics to maintain existing operations and rail traffic.

2. OCS conductors shall, immediately after installation, be grounded in a manner subject to the approval of Houston Metro, and remain grounded until such time as they are placed in service. The Contractor shall ground, in a similar manner, all other aerial conductors within 10 feet of the OCS which are not in service.

3. Coordinate all interface work with Houston Metro.

4. Excavations made adjacent to the track work area shall not remain open more than forty-eight (48) hours, follow the Project Safety Plan and must be
cordoned off and covered to prevent a hazardous condition to the public, Houston Metro and Contractor personnel.

5. The Contractor shall be responsible for the protection of existing equipment and facilities while working on the system. Any damage to the system shall be repaired to the satisfaction of the Houston Metro.

D. Light Rail Vehicle Interface:

1. The light rail vehicle and pantograph characteristics can be made available to the Contractor from Houston Metro upon request.

2. Train Consist:
   a. The standard train for the purpose of design and testing will consist of one to two cars coupled together.
   b. Under normal operations, the train will consist of 2 cars coupled together during rush hours and special events and 1 or 2 cars at all other times.

E. HOUSTON METRO Light Rail Line Interfaces:

1. See Article 1.5.A.2 above.

2. The Contractor shall not disrupt, inhibit or in anyway interfere with Houston Metro’s Light Rail Line revenue service.

1.6 INTERFACES TO EXISTING OCS SYSTEM

A. The Contractor shall develop and submit a detailed interface plan for installing all new OCS, modified existing OCS and for tying-in the new OCS system into the existing OCS system per the final configuration shown on the Contract Drawings. The plan shall cover detailed implementation, staging sequence, temporary structures, terminations, and step by step cut-over requirements.

1.7 INTERFACES WITH NEW SIGNAL SYSTEM

A. The layout and installation of the new OCS structures have been coordinated, as much as possible, with the layout and installation of the new wayside signal equipment (i.e., gates, flashers, signal aspects, pushbuttons, etc). However, the Contractor is responsible for bringing any/all conflicts to the timely attention of Houston Metro so that relocation of equipment, if necessary, can be made without affecting either system and, in particular, the clear sighting distance of the light rail signals.
SECTION 17303 INTERFACE REQUIREMENTS

PART II - PRODUCTS

NOT USED

PART III - EXECUTION

NOT USED

END OF SECTION
SECTION 17305 – DESIGN AND INSTALLATION REQUIREMENTS

SECTION 17305

DESIGN AND INSTALLATION REQUIREMENTS

PART I - GENERAL

1.1 SUMMARY

A. Description:

1. This Section covers the design and installation of the Overhead Contact System (OCS) which is broadly defined as those conductors and related items, forming the overhead power distribution system and comprises the messenger and contact wires, ancillary pull-offs and backbones wires, hangers, feeder cables, jumpers, sectioning devices, tensioning units and systems and ground connections, together with their related supports, hardware, equipment and insulation.

2. The Contractor shall be responsible for coordinating the Contact System installation with the staging and interface requirements set forth in the Section 17303. The Contractor shall submit detailed plans for all proposed temporary anchorages, guying, electrical isolation and protection required to turn over discrete sections of the system to the Administration for its use as required in Section 01110. The Contractor shall also coordinate electrical and service outage requirements for connecting new adjacent sections of the OCS system to those existing portions in use by HOUSTON METRO. Such outages will generally be limited to night or weekend hours during non-revenue periods due to HOUSTON METRO’s commitment to provide scheduled revenue service to the patrons of the light rail system.

B. Related Sections:

1. 17303 - Interface Requirements
2. 17310 – Overhead Contact System Tubular Poles
3. 17313 – Wide Flange Metal Poles
4. 17319 - Supporting Devices
5. 17321 – Galvanized Steel Wire & Wire Rope
6. 17325 – Surge Arrestors
7. 17323 - Stainless Steel Wire Rope, Strand and Rod
8. 17327 - Insulators
9. 17329 - Section Insulators
10. 17331 - Tensioning Devices
11. 17333 - Fittings and Hardware
12. 17341 - Uninsulated Conductors and Cables
13. 17352 – Insulated Feeder Cable
14. 17361 - Special Tools
SECTION 17305 – DESIGN AND INSTALLATION REQUIREMENTS

1.2 REFERENCES

None

1.3 SUBMITTALS

A. The Contractor shall prepare and submit a complete and detailed OCS assembly, component and equipment design including a tabulated allocation of all parts for the OCS System, which is based on the design shown on the Contract Drawings and Specifications.

1. Design Criteria - The basis for the design and construction shall be as shown on the Contract Drawings and in accordance with the HOUSTON METRO Light Rail Design Criteria. Any deviations from the criteria shall be expressly approved by HOUSTON METRO before proceeding with the detailed design. The initial design submittal documentation shall specifically set forth the relevant design criteria as given.

2. Details - The Contract Drawings indicate details where in some cases, such as conductor sizes and types, variations will not be accepted and in other cases, such as OCS hardware, proven designs may be substituted for that which is shown.

3. Design - The Contractor shall select and develop a full arrangement of performance-proven OCS System assemblies and components and shall demonstrate by means of engineering calculations, that all elements of the selected system are capable of meeting design criteria, safety and operational requirements as stated in the specifications and Contract Drawings. Calculations may consist of either computations developed by hand on standard 8½”x11” pages or computer-based solutions. When computer programs are proposed for use, the Contractor shall submit a complete description of the methodology and assumptions which are integral to the program to HRT, which must comply with the design criteria.

a. All component design must be based on the "Working Stress" method, theory of elasticity basis. All safety factors will be proportioned to a materials yield stress or if a material does not exhibit a yield point, the safety factor shall be proportioned to rupture (failure) stress, but with an appropriate increase.

b. The design of the OCS hardware shall be prepared on standard size drawings, for all project, OCS assemblies and components.

c. All design basis, data, calculations and design results shall be checked and bound with a Table of Contents and the full volume shall bear the seal of a registered professional engineer (State of Texas) qualified by
SECTION 17305 – DESIGN AND INSTALLATION REQUIREMENTS

experience, who personally supervised the preparation of the entire design.

B. The application engineering, which shall be performed by the Contractor, shall adhere to the following program and sequence of submittals to HRT:

1. Initial: The Contractor shall prepare an initial submittal which explains the divisions of work among his forces, indicating the suppliers of all OCS equipment, style of equipment selected and qualification of the Contact System design engineer. The design engineer will assemble and submit a summary of all design criteria, preliminary assembly drawings, design assumptions, analytical methodology, computer programs and other data explaining the proposed design approach. This submittal shall be reviewed and accepted by HRT prior to the Pre-Final submittal.

2. Pre-Final: The Contractor's design engineer shall prepare a completely detailed design for the entire Overhead Contact System. This design will use either manually developed or computer based calculations to obtain all design loads for various OCS components to be used on the system. The design shall stipulate where any deviations from the as-planned design or design criteria occur. All loads shall be clearly identified as to location and component, in clear tabular formats. This submittal shall be reviewed and accepted by HRT prior to the Final submittal.

3. Final: The Contractor shall assemble and submit for approval a complete package of allocation drawings, component shop drawings, assembly and sub-assembly drawings for the OCS. All drawings for load-carrying components must have an indication as to the component's load capacity. Fabrication of components shall not proceed until HRT has accepted these submittals.

PART II - PRODUCTS

NOT USED

PART III - EXECUTION

3.1 INSTALLATION OF MISCELLANEOUS ITEMS

A. Insulators:

1. All insulators shall be cleaned before installation. Only clean rags, free from any abrasive material shall be used for cleaning insulators. Wire brushes shall not be used for cleaning any parts, metal or otherwise. In the completed line, all insulator assemblies and hardware shall be clean, bright and free from nicks, chips or other mars.

B. Hardware:
1. All pole-line hardware shall be installed as shown on the Contract Drawings and as recommended by the manufacturer. Bolts and nuts shall be properly tightened in accordance with the manufacturer's recommendations. All bolts shall be of sufficient length for a full thread to show beyond the nut and/or locknut, but shall not protrude beyond the nut and/or locknut more than ½", excluding foundation bolts. Bolt ends shall not be cut off. Where locknuts are not used, lock washers shall be provided.

2. Hardware shall be installed using tools and methods specified and/or approved by the manufacturer.

3. Hardware shall be inspected for cleanliness and damage. Any item that does not fit creates scraping of galvanizing during installation or is found defective shall be rejected.

4. Cotter pins shall be installed with the open end toward the ground.

C. Connectors:

1. Current-carrying connectors shall be as shown on the Contract drawings and shall be installed in accordance with the manufacturer's recommendations. Connectors for copper or bronze wire shall be copper or bronze or a combination of copper and bronze.

2. Bolts in bolt-type connectors shall be lubricated as recommended by the manufacturer and torqued to the manufacturer's recommendation, using a calibrated torque wrench. After the torque requirements are met, use "match-marks" to denote the torque setting point.

3. Where practicable and available, the connectors shall be factory-loaded with a corrosion inhibitor which is made for the specific purpose.

4. Wire surfaces which are in contact with conducting surfaces of the connector shall be thoroughly wire brushed and an inhibitor applied. Where connectors are not factory-loaded, the same inhibitor shall be applied in the field to the connector.

5. Corrosion inhibitors shall be stable over a wide temperature range, adhere to cold metal surfaces, be water-repellent, weather resistant and inert to copper, aluminum, zinc, tin, cadmium, steel and neoprene rubber. Grit-bearing inhibitors shall be used except for flat lugs, sliding surfaces or where recommended by the connector manufacturer. Grit shall be compatible with the connector and wire metal. Inhibitor for copper and bronze shall be T&B "Kopr Shiel", Fargo "Fargolene", Penn-Union "Cual-Aid", Burndy, "Penetrox A" or approved equal.

6. One typical full-tension test of each type of wire splice for each type of conductor
SECTION 17305 – DESIGN AND INSTALLATION REQUIREMENTS

shall be fabricated independent of the OCS and shall be tested by the Contractor's independent testing laboratory. The tensile strength and electrical conductivity of full-tension line splices shall be at least equal to the values specified in NEMA Standard CC3 for Class 1, Full-Tension connectors. Copper and bronze line splices shall conform to the specified standard of 95 percent tensile strength and 100 percent conductivity (minimums).

7. Contact wire splices shall be designed to avoid the formation of "Hard Spots" in the OCS system. Maximum separation of spliced contact wires shall be 1/32 of an inch.

D. Conductors:

1. For each length of conductor run installed, a record shall be kept of the reel number from which the conductor was used. Partially used reels shall be recorded as such.

2. All conductors shall be handled in accordance with good overhead line practice and as per the manufacturer's recommendations.

3. Conductors shall normally be ordered with several lengths of conductors on one reel to satisfy several anchor-to-anchor runs. They shall be supplied in one length. As each anchor-to-anchor length is removed, the length remaining on the reel shall be re-computed and properly recorded both on the reel and on substantiating documentation.

4. Care must be taken with reels so as not to prejudice the stringing operation. Damaged reels shall be set aside for repair or replacement before use.

5. Cables in manholes shall be arranged on Contractor furnished insulated racks and secured with cable ties with the ends of cables sealed against moisture if connections or splices are not completed.

3.2 INSTALLATION OF OCS

A. OCS wire runs shall not be erected without the free-standing tandem termination structure or pole guy anchor assemblies being in place, ready to receive loads.

B. Care shall be taken to prevent kinks in the OCS wires and cables. HRT reserves the right to reject any contact wire in its entirety if it is judged that any kink will prejudice current-collection performance. Bird caging of stranded wire shall be cause for rejection.

C. Tensions in all conductors shall be as given in temperature-tension charts, +/- 5 percent.

D. Splicing of conductors is not acceptable in any in-running contact wire (one which is in contact with the pantograph) except as shown on the Contract Drawings or with the approval of HRT.
SECTION 17305 – DESIGN AND INSTALLATION REQUIREMENTS

E. Typically no splices are to be used in the OCS contact wire. One (1) splice will be permitted in the messenger wire in any one OCS tension length, but only with prior authority approval, unless otherwise shown on the Contract Drawings.

F. No splice will be permitted within 5 feet of a support clamp.

G. Any damage to the conductors shall be reported, in writing, to the Engineer. Remedial action must be approved by the Engineer and will be performed as directed.

H. The Contractor shall provide any temporary anchors and down guys required to facilitate system installation and construction staging. All temporary arrangements shall be approved by the Engineer prior to erection.

3.3 ERECTION OF BALANCE WEIGHT ANCHOR (BWA) DEVICE

A. The BWA device shall be installed as shown on the approved shop drawings and as recommended by the manufacturer.

B. It is suggested that the Balance Weights are pre-positioned at the mean temperature (70°F) position inside the pole and locked during OCS installation so that vertical travel is prevented. Tensioning of the messenger and contact wires can then be effected in accordance with the Erection Tensions as shown on the Drawings. This method permits cantilevers and pull-offs to be set perpendicular to track for messenger suspension clamp tightening. It avoids the need to calculate along-track offsets (resulting from temperature variation) or cantilever swing setting and clamping as it would if the conductor tensioning is undertaken with the weights free to move.

3.4 ERECTION OF SPRING TENSIONING DEVICE

A. The spring tensioning device shall be installed as shown on the approved shop drawings and as recommended by the device manufacturer.

3.5 PREPARATION FOR STRINGING MESSENGER WIRE

A. Roller-bearing sheaves of the closed type shall be used at all support points for stringing of the messenger wire. Sheaves shall be of sufficient size to accommodate the conductor without damage.

B. Stringing of the messenger shall start from a fixed anchor location. After the initial termination is made, the conductor shall be pulled from the reel and lifted into the sheaves at each support. Sufficient tension must be maintained in the conductor during stringing to ensure that, under no circumstances, does the conductor touch the ground or track between support points.

C. When the second anchor location is reached, the messenger conductor shall be tensioned above the specified erection tension by 1,500 lbs. This tension shall be held
SECTION 17305 – DESIGN AND INSTALLATION REQUIREMENTS

for a minimum of twelve (12) hours and then slackened to the specified erection tension and the dead-end assembly attached. In certain locations, due to track/OCS outage constraints, the messenger wire may have to be placed in a temporary position to allow for pre-tensioning.

D. Erection tensions shall be governed by tables furnished for this purpose, based on the equivalent span for the tension length and actual temperature of the conductor (not air temperature).

E. At OCS structures adjacent to overhead obstructions, when there is a possibility of interference, the conductors shall be lowered temporarily clear of those obstructions. Acceptable clearances shall be maintained at all times to the track and/or at cross streets and grade crossings.

3.6 ADJUSTING MESSENGER WIRE STRINGING TENSION

A. Final adjustment to the specified stringing tension shall be made progressively, working any slack from the first anchor location toward the second anchor location at the other end of the run.

B. The tension shall be adjusted so that it will be within 5 percent, plus or minus, of the erection tension derived from the tables.

C. When the proper tension has been obtained, the messenger suspension clamps at each support point shall be tightened to the manufacturer's specified torque onto the stranded conductor.

3.7 INSTALLING MID-POINT AND TENSION REDUCTION ANCHORS

A. Install the mid-point anchor to mid-point messenger support as shown on the Contract Drawings and as recommended by the manufacturer.

B. Install the tension reduction anchor to tension reduction messenger support as shown on Contract Drawings and as recommended by the manufacturer.

3.8 INSTALLING HANGERS

A. As-built span lengths between messenger support points are to be field measured during construction and each OCS span of hanger lengths calculated from the tables and formulae given in the Contract Drawings.

B. Hangers shall be manufactured to a tolerance of +/- ¼" in length.

C. The along-track position of each hanger shall be within +/- 2” of the design position.

D. Hangers are not to be cut to their final length or fully crimped until the final acceptance by HRT. Temporary “Crosby” clips shall be used prior to final, permanent crimping.
3.9 STRINGING AND TENSIONING CONTACT WIRE

A. The contact wire shall be erected in temporary wire loops attached to the ends of the hangers. "Figure Eight" loops made of No. 9 iron wire annealed or other approved loops, may be used. In any case, the contact wire shall not be restrained from longitudinal movement during tensioning.

B. Contact wire shall be held in proper lateral position, in relation to the centerline of track, using temporary rollers to prevent kinking.

C. Contact wire shall be tensioned in accordance with the tension values shown on the Drawings for the appropriate equivalent span and temperature. The contact wire should be over tensioned by 1,000 lbs. and held for a minimum of twelve (12) hours before reducing to the specified tension and making the final termination. In certain locations, due to track/OCS limitations or outage constraints, the contact wire may have to be placed into a temporary position to allow for pre-tensioning.

3.10 TENSION CONDITIONS

A. Conductor temperatures shall be measured by using a thermometer. The bulb of the thermometer shall be in intimate contact with the conductor and shall be closely taped to the conductor to prevent drafts around the bulb. The conductor shall be in “free air” and not in direct sunlight or shade at the time of temperature measurement. The thermometer shall be read after 5 minutes of contact.

B. A record of temperature and the tension recorded at both ends of the tension sections shall be kept for all OCS wire runs.

3.11 ATTACHING HANGER CLIPS AND REGISTRATION ARMS

A. As the hanger clips are fastened and steady arms attached, any twist in the contact wire shall be removed by working from one anchor to the other.

B. As far as practicable, bolts shall be installed in the various clips so that the nuts will be on the same side giving a uniform appearance. On curves, the nuts shall be placed on the inside of the curve to provide the best clearance to the pantograph.

C. Saddles for loop-type hangers shall clamp the messenger tightly. The loops shall have a loose fit around the saddle, permitting free hanger rise and fall without binding.

D. Wire pull-offs shall be installed in locations designated on the approved layout drawings.

3.12 INSTALLATION OF BRIDLE WIRES

A. Bridle wires shall be installed in pulley wheel supports as shown on the Contract drawings.
SECTION 17305 – DESIGN AND INSTALLATION REQUIREMENTS

Drawings.

B. The messenger wire, messenger wire bridle loop and fittings shall be capable of accommodating the full messenger wire current.

C. The messenger wire bridle loop and fittings shall not restrict the along track movement of the Contact System throughout the full range of the specified temperature range.

D. The tension division between the messenger and bridle wire shall be as recommended by the manufacturer. In no case shall the bridle wire tension exceed 75 percent of the normal unbridled messenger tension.

E. The Contractor shall submit for review and approval his installation methods for the bridle wires prior to proceeding with the work.

3.13 INSTALLATION OF WIRE CROSS ASSEMBLIES

A. Crossed-contact wire assemblies (i.e., wire crosses or contact wire bridges) shall be fitted at all in-running contact wire crossings as shown on the Contract Drawings.

3.14 INSTALLATION OF JUMPERS

A. Jumpers shall be installed as shown on the Contract Drawings and at other locations as may be required by the Engineer.

B. Before fitting jumper clamps, the conductors shall be wire-brushed, to ensure a good electrical connection to the jumper clamps and a manufacturer’s recommended inhibitor applied to the conductors.

C. Jumper ends shall protrude through their clamps a minimum of ½” and a maximum of 1”.

D. The configuration and length of jumpers shall make due allowance for the relative movement between catenaries for all temperatures.

3.15 CONTROL OF SCRAP

A. Scrap components shall be segregated from usable components, collected and removed from the site daily.

B. Scrap components shall not be left alongside the track.

C. Scrap components are the property of the Contractor and shall be removed from the project.

3.16 FINAL ADJUSTMENT

A. After tensioning has been completed and any temporary stops at the balance weight
 anchors removed, hangers and clips fastened, steady arms erected and pull-offs installed, a check of the OCS construction and adjustment to final position shall be made. This checking shall also include the areas of existing OCS that is over-lapped or spliced into or with the new installed OCS. Particular attention shall be paid to the plumbness of hangers, the along-track position of cantilevers (and bridles at head-span and intersection backbone structures) and the setting of balance weights. The Contractor shall be responsible for making all necessary adjustments to existing OCS components that have been affected by new work.

B. Construction at overhead bridges shall be checked for proper contact wire height and for clearance from the messenger to the underside of the bridge.

C. Any hangers with improper fit shall be replaced with hangers of proper length.

D. Height of contact wire and lateral position of wire shall be checked in accordance with the approved layout drawings and adjusted where necessary and is to be measured normal to the track along the elevated centerline.

E. The contact wire height given in the OCS Layout drawings is to be the height at mean ambient temperature (60°F).
   1. Where the normal height of contact wire is 19'-6" and above, a tolerance of +3", -0" from the height shown on the OCS Layout drawings will be permitted.
   2. Where the wire is shown less than 19'-6" in order to be clear of low headroom overhead bridges, a tolerance of +½", -0" will be allowed.
   3. Mid-span heights must be at the average of the support heights at the structures at each end of the span; +/- 1" for spans less than 100 ft, +/- 2" for spans 101 ft to 200 ft, +/- 3" for spans over 200 ft.

F. The staggers of the contact wire shown in the approved layout drawings are relative to the inclined centerline of track, which coincides with the nominal centerline of the static pantograph.

G. Generally, on tangent track, the stagger of the contact wire will be alternately to the right or left of the centerline of the pantograph at consecutive structures.
   1. The lateral position of the contact wire on curved track will vary with the curvature and span length. The stagger at each support will be as shown on the OCS Layout drawings.
   2. The installation tolerance for contact wire stagger shall be +/- ½" on the values specified on the OCS Layout drawings. When required to achieve acceptable mid-span offset, this tolerance may be increased with the approval of the Engineer.
SECTION 17305 – DESIGN AND INSTALLATION REQUIREMENTS

3. If the construction indicates that changes are required, the subject shall be brought to the attention of the Engineer at once.

H. The messenger wire shall be installed vertically above the final contact wire stagger with an allowance of +/- ½" for system heights up to 1’-6”, increasing to +/- 1” for system heights of 3’-0” or greater.

3.17 MEASUREMENT OF THE CONTACT WIRE AT STRUCTURES AND AT MIDSPAN

A. The following measurements shall be made and recorded with the OCS installed in its final position.

1. Contact wire height above each track at each messenger support point and at mid-span.

2. Wire temperature and air temperature including time of day.

3. Contact wire stagger relative to as-built super-elevated track centerline at each registration point and at mid-span.

4. Track centerline to face of pole clearance at rail level at each structure location, actual track super-elevation and as-built pole rake.

B. A complete set of the final height and stagger dimensions, as accepted, shall be available at the Final Inspection and incorporated into the final OCS as-built documents.

C. Clearance Check: The Contractor shall make a clearance check, using the height and stagger gauge fitted with the removable clearance ears. If fouling occurs at any point, it shall be brought to the attention of HRT immediately.

1. The clearance ears shall allow for 4” of uplift of the contact wire with an additional allowance of 3” for mechanical clearance. All parts of the system shall be outside this clearance envelope, with the exception of the steady arm. All registration pipes drop brackets, when used and attached to the steady arm, shall be outside the clearance envelope.
3.18 PRECAUTIONS IN HANDLING CONDUCTORS

A. All conductors shall be handled in such a manner that they will not be scratched, cut or nicked with tools or clamps.

B. Conductors shall not lie upon or be dragged across, sharp or rough surfaces.

C. Conductors which are or become, annealed shall be replaced without exception.

D. Sharp bends shall not be put in the conductors.

E. Conductors shall not be looped to form dead-ends of either a temporary nature or a permanent nature.

F. Conductors shall not be wrapped around poles or other anchorages.

G. Conductors shall not be marred with temporary wire or hook hangers.

H. Only approved parallel jaw clamps shall be used in tensioning all conductors. The grooves of the clamps must be free from burrs, fins or any roughness and the ends of the grooves must be flared (bell-shaped).

I. Vertical kinks in the contact wire shall be removed. A leather or copper-faced hammer shall be used, beating against a smooth flat surface. A 4" x 4" x 4' hardwood block is recommended. Other methods may be approved by HRT contractor shall provide performance data for review.

J. Lateral kinks in the contact wire shall be removed if they affect the fit of any parts or are judged prejudicial to good current collection by HOUSTON METRO.

END OF SECTION
SECTION 17307 – BASIC ELECTRICAL MATERIALS AND METHODS

PART I - GENERAL

1.1 SUMMARY

A. Description:

1. The work of this Section covers the furnishing electrical materials and installation methods applicable to the OCS electrical work specified in other Sections, except as modified in those Sections.

B. Related Sections:

1. 17316 - Grounding and Bonding of Assemblies
2. 17325 - Lightning Arresters
3. 17335 - Pole Mounted Disconnect Switches
4. 17351 - Testing
5. 17352 - Traction Power - Insulated Feeder Cable

1.2 QUALITY ASSURANCE

A. Materials specified shall meet the requirements of the cited references.

B. Production tests shall be performed on materials and certified by the Manufacturer.

1.3 REFERENCES

<table>
<thead>
<tr>
<th>Organization</th>
<th>Number</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANSI</td>
<td>C80.1</td>
<td>Specifications for Rigid Steel Conduit, Zinc Coated</td>
</tr>
<tr>
<td>ASTM</td>
<td>B3, B8</td>
<td>Specifications for Stranded and Solid Conductors</td>
</tr>
<tr>
<td>ASTM</td>
<td>B633</td>
<td>Specification for Electro-deposited Coatings of Zinc on Iron or Steel</td>
</tr>
<tr>
<td>ASTM</td>
<td>D149</td>
<td>Tests for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies</td>
</tr>
</tbody>
</table>
SECTION 17307 – BASIC ELECTRICAL MATERIALS AND METHODS

ASTM D570 Test for Water Absorption of Plastics

ASTM D635 Test for Rate of Burning and/or Extent and Time of Burning of Self-supporting Plastics in a Horizontal Position

ASTM D638 Test for Tensile Properties of Plastics

ASTM D695 Test for Compressive Properties of Rigid Plastics

ASTM D790 Tests for Flexural Properties of Un-reinforced and Reinforced Plastics and Electrical Insulating Materials

ASTM D2240 Test for Rubber Property - Durometer Hardness

ASTM E84 Test for Surface Burning Characteristics of Building Materials

FS W-F-408 Fittings for Conduit, Metal, Rigid (Thick Wall and Thin Wall) (EMT) Type

NEMA RN 1 Polyvinyl-Chloride Externally Coated Galvanized Rigid Steel Conduit

NEMA TC 2 Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80)

NEMA TC 3 PVC Fittings for use with Rigid PVC Conduit and Tubing

NEMA WC 7 Cross-Linked-Thermosetting-Polyethylene Insulated Wire and Cable

NEMA WC 8 Ethylene-Propylene-Rubber Insulated Wire and Cable

NEMA WD 1 General Purpose Wiring Devices

NFPA 70 National Electrical Code (NEC)

NESC 2007 National Electrical Safety Code

UL 6 Rigid Metal Conduit

UL 83 Thermoplastic-Insulated Wires and Cables

UL 467 Grounding and Bonding Equipment
SECTION 17307 – BASIC ELECTRICAL MATERIALS AND METHODS

UL 651 Schedule 40 and 80 Rigid PVC Conduit

UL 1059 Terminal Blocks

1.4 SUBMITTALS

Submit the following:

A. Manufacturer's description, shop drawings, installation and operational instructions for all material described in this Section which is utilized in the work.

PART II - PRODUCTS

2.1 GENERAL

A. Materials furnished shall be standard products of manufacturers regularly engaged in the production of the materials specified.

2.2 GALVANIZED RIGID STEEL CONDUIT (GRS)

A. Conduits, Couplings, Elbows, Bends and Nipples shall be hot-dip galvanized and meet the requirements of ANSI C80.1 and UL 6.

B. Conduit Straps, Clamps, Back and Spacers - Hot-dip galvanized malleable iron.

C. Conduit Fittings and Accessories shall be galvanized steel and meet the requirements of FS, W-F-408.

2.3 POLYVINYL CHLORIDE (PVC) COATED GALVANIZED RIGID STEEL CONDUIT AND ACCESSORIES

A. Coated conduits, elbows, and couplings shall comply with NEMA RN1, Type A coating.

2.4 PVC CONDUIT AND FITTINGS

A. Conduits: Shall comply with NEMA TC 2 and UL 651, Schedule 40 or 80 as required, and have the following properties:

1. Flammability: ASTM D635, self-extinguishing

2. Tensile Strength: ASTM D638, 6000 psi at 78° F

3. Flexural Strength: ASTM D790, 12,500 psi

4. Compressive Strength: ASTM D695, 4000 psi
SECTION 17307 – BASIC ELECTRICAL MATERIALS AND METHODS

5. Hardness: ASTM D2240 (Durometer D), 77

6. Water Absorption: ASTM D570, 0.03% maximum, in 24 hours at 72° F

7. Dielectric Strength: ASTM D149, 1100V per mil

B. Conduit cement and primer: As recommended by the conduit manufacturer.

C. Fittings: NEMA TC 3.

D. Spacers: Styrene, interlocking type.

2.5 CONDUIT EXPANSION FITTINGS

A. The end couplings shall be of the same material as those of the conduits to be coupled.

B. Neoprene sleeves attached to the end couplings by stainless steel bands shall accommodate an axial expansion or contraction from normal of 3/4" minimum in either direction, parallel misalignment of the axis of coupled conduit runs, in any direction, of 3/4" minimum, and an angular misalignment of the axis of coupled conduit runs, in any direction, of 30° minimum.

C. A tinned flexible copper braided bonding jumper, integral with the expansion fitting, shall be attached to the end couplings to provide electrical continuity for all metal conduits.

2.6 GROUNDING AND BONDING MATERIALS

A. Grounding and bonding materials shall comply with UL 467.

B. Ground Rods: Medium carbon steel core, copper clad by the molten weld casting process and have a conductivity of not less than 27 percent of pure copper. Rods shall be not less than 3/4" diameter and 10' in length as indicated.

C. Ground Conductors: ASTM B3, Class B stranded annealed copper and sized as indicated on the Contract Drawings.

D. Connectors: Buried ground connections shall be exothermic welded as indicated on the Contract Drawings.
2.7 INSULATED WIRE, CABLE AND ACCESSORIES

A. Unless otherwise specified, conductors for general use shall be soft or annealed copper complying with ASTM B8, Class B stranded. Insulation level shall be 2,000V NEC type XHHW conforming to NEMA WC 7 or type RHW conforming to NEMA WC8.

B. All terminations and cable terminal connections shall meet or exceed the capacity and insulation voltage ratings of the wire or cable terminated.

C. All feeder cable and insulated wire runs shall be identified at each end of the run, and also at all manholes, vaults and pull boxes. Wire identification markers/tags shall be water resistant, self-laminating vinyl with opaque-blank write-on section. Permanent ink markers shall be used to complete these tags. A transparent adhesive wrap shall be used to secure and protect the tag on the cable.

D. Wire ties shall be a heavy-duty nylon type strap with stainless steel locking barbs sized to suit application, and ultraviolet ray (sunlight) resistant. Wire ties for supporting feeder or surge cables shall be nylon coated stainless steel ties with 250 lb tensile strength.

PART III - EXECUTION

3.1 GENERAL

A. Installation work shall be in accordance with applicable requirements of NFPA 70 and shall comply with the regulations of NEC and IBC.

B. Materials and equipment shall be applied, installed, and connected as recommended by the manufacturer.

3.2 CONDUIT, FITTINGS, AND ACCESSORIES

A. Embedded Conduits:

1. The ends of conduits shall be capped or covered prior to concrete placement.

2. Embedded conduits shall be properly supported and braced prior to concrete placement or backfilling.

3. Conduits shall be pitched to provide moisture drainage to the vault or pull box, if physically possible.
4. Conduits shall be rodded or wire brushed and swabbed clean prior to cable installation, to remove foreign matter. After cleaning, pull strings shall be installed in all conduits, including spares. Conduit ends shall be capped until cable pulling commences.

5. Where conduits cross structural expansion joints, conduit expansion fittings, as specified, shall be installed at the expansion joints.

6. The ends of field cut conduits shall be reamed and de-burred to remove rough edges. The ends of PVC conduits that are to be joined shall be coated with conduit cement for a length equal to the depth of the coupling or other fitting, to ensure a watertight connection.

B. Exposed Conduits:

1. Unless otherwise noted, exposed conduits shall be Galvanized Rigid Steel (GRS), or, with the Engineer’s permission, rigid Schedule 80 PVC conduit.

2. Conduit runs shall be made with approved couplings and unions. Right angle bends, offsets and change-in-direction bends shall be made with standard elbows, conduit fittings and pull boxes. Runs shall be straight and true; with elbows and bends uniform and symmetrical. Bends with kinking and deformed cross-sectional contours are not acceptable and will be corrected.

3. Rigid PVC conduit joints shall be made using a surface primer and final cement application, unless recommended otherwise by the conduit manufacturer.

4. Conduits entering outlet boxes, pull boxes, enclosures, cabinets and similar equipment enclosures shall be attached to the box or enclosure with a locknut on both the outside and inside, each tightened. Conduits shall be provided with end bushings.

5. Conduit clamps and supports shall be used on all runs, elbows, and ends to securely fasten the conduit to the pole or support structure. They shall be suitable for the conduit size intended and act to secure the conduit during the wire pulling operations.

6. All conduit runs shall be cleared and swabbed to remove foreign matter after final installation, prior to pulling in wire and cable. The Contractor installing the conduit runs will provide this function without exception.

7. After cleaning/proofing the conduits, pull strings shall be installed in all conduits, including spares. Conduit ends shall be capped until cable-pulling commences.
3.3 GROUNDING

A. Personnel Ground Mat (If Utilized):

1. Personnel ground mats shall be installed below finish ground level at every special application location shown, unless specifically deleted by the Engineer.

2. Personnel ground mats shall be of a minimum #6 AWG bare copper wire on 6"x6" spacing. Overall mat size shall not be smaller than 4'x6'.

3. The personnel ground mat shall be bonded to the OCS pole which supports the disconnect switch, as shown on the Contract Drawings.

B. Buried Ground Conductors:

1. Grounding mat conductors shall be as specified. Size of conductor, depth of burial, and arrangement of grid shall be as indicated, on the Contract Drawings.

2. Conductor splices, joints, and connections shall be made by the exothermic copper oxide reduction weld method.

3. Finish welds shall be cleaned and coated with an approved cold applied bituminous resin compound. Primer shall be as recommended by the coating manufacturer.

C. Ground Rods:

1. Ground rods shall be driven vertically to the depth needed to achieve the specified resistance to earth. The ground rod point shall be provided with a steel alloy cone on the driven end and provided with a removable driving stud. Multiple ground rods shall be used to achieve the specified resistances where necessary.

2. Ground rods shall be separated from adjacent buried metallic structure or pipe by a minimum of five (5) feet.

D. Connections Above Ground:

1. Above grade (exposed) grounding connections shall be accomplished using fittings and clamps expressly manufactured for grounding use. Connectors shall be compatible to and listed for their attachment, including connection to wires, cables, equipment, support hardware and OCS components and/or steelwork.
2. Acceptable connectors include bolted, compression, wedge driven and grounding clamps. Connections made using the exothermic copper oxide reduction weld method are also acceptable means of accomplishing above grade connections.

3.4 INSULATED WIRE, CABLE AND ACCESSORIES

A. General:
   1. Wire and cable shall be installed by means of equipment, devices, and methods recommended by the manufacturer. High voltage cable terminations shall be performed by qualified personnel only, utilizing only tools rated to perform the job properly.
   2. Wiring and cabling shall be terminated and connected by means of connectors, lugs, and other methods specified.

B. Power Cabling:
   1. DC circuits consisting of multiple single conductors shall be grouped and pulled together in the designated conduit or duct. Conductors shall be continuous from end to end without splices. Adequate slack (3 feet minimum) shall be provided at terminations and in pull boxes, hand-holes and manholes. Strain relief bushings shall be used the feeder cable in the feeder pole spouts.
   2. Cables shall be identified by individual permanent tags at each end of circuit and at any intermediate pull box, handhold, or manhole by specified markers.

3.5 WIRING DEVICES

A. Wire Termination: Power wiring shall be terminated with approved connectors. Provide adequate slack wire, one loop minimum, to prevent strain on termination.

3.6 FIELD TOUCH-UP

A. Galvanized Metal Surfaces: Coat damaged surfaces to meet the finish of the original coating, with polystyrene organic rich compound containing not less than 91 percent by weight metallic zinc powder in dried form.

B. Painted Metal Surfaces: Clean, treat, and coat damaged surfaces with required rust inhibiting undercoating and finish coat paint system in accordance with paint manufacturer's instructions.
C. Fiberglass Reinforced Polyester Enclosures: Repair only minor damaged surface with materials and methods as recommended by manufacturer. Major damage shall require complete component replacement as directed by the Engineer.

END OF SECTION
SECTION 17321 – GALVANIZED STEEL WIRE AND WIRE ROPE

PART I - GENERAL

1.1 SUMMARY

A Description:

1. This Section covers the manufacture, supply and installation of all grades of galvanized steel wire, wire-strand terminations, wire assemblies and wire rope for use as aerial head guys for the Overhead Contact System (OCS), as shown on the Contract Drawings and specified herein.

B. Related Sections:

1. 17305 - Design and Installation Requirements
2. 17319 - Supporting Devices
3. 17333 - Fittings and Hardware

1.2 REFERENCES

A. Pertinent provisions of the following listed standards shall apply to the work of this Section, except as they may be modified herein and are hereby made a part of this Specification to the extent required:

B. American Society for Testing and Materials (ASTM):

   A475 Zinc-Coated Steel Wire Strand

1.3 SUBMITTALS

A. Reports for each type of wire to be used containing the physical and mechanical properties of all components described in this Section shall be submitted. The conformance of components with these Specifications and the Drawings in the form of a manufacturer’s certification shall be shown. Include the following as a minimum:

1. Size
2. Type
3. Material
4. Number of and diameter of individual wires
5. Overall diameter
6. Cross-section area
SECTION 17321 – GALVANIZED STEEL WIRE AND WIRE ROPE

7. Weight per foot
8. Rated breaking strength
9. Project use and product application data

B. Operation (installation) and maintenance manuals shall be submitted for all head guy strands and specialized wire-strand terminations, in accordance with Section 17363.

PART II - PRODUCTS

2.1 DESCRIPTION

A. Components: The zinc-coated stranded wire shall be manufactured and tested in accordance with ASTM A475.

B. Performance: Physical properties of the zinc-coated stranded wire shall conform to the description in Table 1 of ASTM A475.

C. Materials: The material used for stranded steel wire and wire components shall conform to ASTM A475.

D. Zinc Coating: The weight of coating for zinc-coated steel wire shall not be less than that specified in Table 4, under Class C of ASTM A475.

2.2 CERTIFICATION

A. The Contractor shall provide certification that the galvanized steel wire and wire rope have been designed, fabricated, rated and tested in compliance with the applicable provisions of the standards referenced in these Specifications.

PART III - EXECUTION

3.1 DELIVERY AND MARKING

A. Materials shall be protected against damage in ordinary handling and shipping. Each reel shall have a strong, weatherproof tag securely fastened to it showing the physical and mechanical properties as well as the steel type designation, ASTM designation and the name and mark of the manufacturer.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Galvanized steel wire and wire rope shall be cut and installed using tools and methods specified by the manufacturer.
B. Splicing of the galvanized steel wire and wire rope will not be permitted under any circumstances.

3.3 INSTALLATION OF AERIAL HEAD GUYS

A. Aerial head guys shall be installed before the section insulators are installed. They shall be pulled taut and secured in place with provisions for future adjustment as required to support the section insulator in proper alignment after the contact wire is installed to its final configuration and tension.

B. Aerial head guy terminations and attachments shall be installed as recommended by the manufacturer.

C. The Contractor shall make all final adjustments necessary to the aerial head guys to compensate for initial stretch to insure the proper long-term support and alignment of the section insulators.

END OF SECTION
SECTION 17323 – STAINLESS STEEL WIRE ROPE AND ROD

SECTION 17323

STAINLESS STEEL WIRE ROPE, STRAND AND ROD

PART I - GENERAL

1.1 SUMMARY

A. Description:

1. This Section covers the manufacture, supply and installation of stainless steel wire rope, stainless steel wire strand and stainless steel rod for the Overhead Contact System (OCS), as shown on the Contract Drawings and as specified herein. This includes the following assemblies:

a. Stainless Steel Wire Rope:
   i. Balance Weight Anchor Assembly (non-rotating)
   ii. Cantilever Nose Hanger Wire
   iii. Bridle Wires (non-rotating)
   iv. All Head-span or Cross-Span Across-Track Wires
   v. Pull-Off Assembly Wire

b. Stainless Steel Wire Strand:
   i. Cross-Span Wire Registration Assembly
   ii. Messenger Wire Knuckle Assembly
   iii. OCS Hanger Wire

c. Stainless Steel Rod:
   i. "Electric Train Stop" Warning Sign Support (if utilized)

2. The stainless steel wire rope, strand and rod shall be suitable for the uses as shown, acceptable for use on a medium speed Overhead Contact System and provide for a usable and maintainable wire arrangement.

B. Related Sections:

1. 17305 - Design and Installation Requirements
2. 17315 - Signage
3. 17319 - Supporting Devices
4. 17331 - Tensioning Devices
5. 17333 - Fittings and Hardware
1.2 REFERENCES

A. The following standards shall apply and are made a part of this specification.

   a. A276 Stainless and Heat Resisting Steel Bars and Shapes
   b. A368 Stainless and Heat Resisting Steel Wire Strand
   c. A492 Stainless and Heat Resisting Steel Rope Wire
   d. A555 General Requirements for Stainless and Heat Resisting Steel Wire
   e. A580 Stainless and Heat Resisting Wire

1.3 SUBMITTALS (CDRL)

A. Certification: Furnish certification verifying that the stainless steel wire rope, strand and rod have been designed, manufactured, inspected and tested in accordance with the referenced standards and these Specifications.

B. Test Reports: Furnish copies of reports of all factory tests as required by these Specifications and referenced standards.

C. Manufacturer's Data: Furnish complete manufacturer's data and technical description.

D. Project Use: Furnish complete size and application data for all types of wire rope, strand and rod used in for the OCS configurations.

1.4 DELIVERY, STORAGE and HANDLING:

A. The wire rope and strand shall be shipped on reels suitable for the weight carried.

B. The rod shall be shipped on reels suitable for the weight carried or in straight lengths, securely bundled. Rods shipped on reels shall be straightened prior to use.

C. All material shall be protected against damage during handling and shipping. Each reel or bundle shall have a strong, weatherproof tag securely fastened showing the physical and mechanical properties as well as type designation, ASTM designation and the name and mark of the manufacturer, the total length and weight of the wire rope, strand or rod on each reel or bundle.
PART II - PRODUCTS

2.1 MATERIALS

A. General:

1. Austenitic grade stainless steel
2. High corrosion resistance
3. Compatible with component items
4. Designed to carry maximum working loads with a factor of safety of 2.5 minimum based on yielding stress.

B. Stainless Steel Wire Rope:

1. Extra flexible
2. Non-rotating, where specified and shown.
3. Manufactured, tested and in conformance with requirements of ASTM A368, A492, A555 and A580.

C. Stainless Steel Wire Strand:

1. Manufactured, tested and in conformance with requirements of ASTM A368, A555 and A580.

D. Stainless Steel Rod:

1. Round
2. Manufactured, tested and in conformance with requirements of ASTM A276.

2.2 FABRICATION

A. Hanger lengths shall be fabricated within a tolerance of +/- ¼" of calculated lengths.

B. All material must be suitable for field adjustment.

C. Installation of wire rope and strand shall be as shown in the Contract Drawings and in accordance with manufacturer's recommendations.
PART III - EXECUTION

3.1 INSTALLATION OF HEADSPAN AND CROSS-SPAN ASSEMBLIES

A. Prior to installation of head-span or cross-span assemblies, the Contractor shall record the following field details and along the axis of the spans for review by Houston Metro:

1. Pole to pole, track to track and track to pole centerline dimensions.
2. Relative cross-track elevation of tops of foundations and tracks.
3. Track super-elevations and directions facing towards higher station numbers.

B. The Contractor shall review and note all field changes from the design and submit these changes together with recommendations to the Engineer.

C. Attachment heights and loadings for cross-spans and headspans shall be fully developed in calculations for each location in accordance with standards shown on the Contract Drawings.

D. Wire sizes, locations of turnbuckles, insulators, suspension assemblies and hangers for the OCS shall be installed in accordance with the Contract Drawings and/or approved shop drawings.

3.2 INSTALLATION OF OCS HANGERS

A. Field adjustments of hangers, contact and messenger heights shall be performed by the Contractor as necessary to maintain the OCS in compliance with all approved designs and shop drawings.

B. Stagger, wire height and heel settings shall be in accordance with the Contract Drawings or as directed by the Engineer.

C. Hangers shall be spaced as shown within a tolerance of +/-2”.

D. No damage to the interfacing components shall occur during installation.

3.3 INSTALLATION OF PULL-OFF ASSEMBLIES

A. Pull-off assemblies shall be installed to hold the OCS system in its correct horizontal alignment on curves.

END OF SECTION
SECTION 17327 - INSULATORS

PART I - GENERAL

1.1 SUMMARY

A. Description:

1. This Section covers the design, manufacture, supply and installation of insulators for the Overhead Contact System (OSC), as shown on the Contract Drawings and specified herein. This work shall include the following:

   a. Cantilever Pipe, Pin and Nose Cap Insulators
   b. Messenger Wire Support Insulators
   c. Messenger Wire In-Span and Termination Insulators
   d. Contact Wire In-Span and Termination Insulators
   e. Contact Wire Insulators (non-riding type without weather-sheds)
   f. Feeder Line-Post and Termination Insulators
   g. Overhead Bridge Support Insulators (if utilized)
   h. Head-span, Cross Span and Aerial Head Guy Wire Insulators
   i. Other Miscellaneous Insulators (as shown on Contract Drawings)

2. This Section requires that all overhead wire OCS System insulators conform to the features and standards stated herein and as shown on the Contract Drawings.

3. All contact wire “riding-type” insulators for use on Section Insulator assemblies are not part of this Section and are specified in Section 17329.

4. The Contractor shall supply and install all applicable insulators for the overhead wires and cables associated with the 750V DC OCS System, in accordance with the requirements specified.
SECTION 17327 - INSULATORS

B. Related Sections:

1. 17305 - Design and Installation Requirements
2. 17319 - Supporting Devices
3. 17329 - Section Insulators
4. 17331 - Tensioning Devices
5. 17333 - Fittings and Hardware
6. 17341 - Uninsulated Conductors and Cables

1.2 REFERENCES

A. Codes and Standards: Pertinent provisions of the following listed standards shall apply:

   b. C29.1 Test Methods for Electrical Power Insulators

   a. A153 Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   b. D149 Dielectric Breakdown Voltage and Dielectric Strength of Electrical Solid Insulating Materials at Commercial Power Frequencies
   c. D229 Rigid Sheet and Plate Materials Used for Electrical Insulation, Method of Testing
   d. D256 Impact Resistance of Plastics and Electrical Insulating Materials, Test Methods
   e. D570 Water Absorption of Plastics, Test Method
   f. D624 Rubber Property Tear Resistance, Test Method
   g. D635 Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position, Test Method
   h. D638 Tensile Properties of Plastics, Test Method
i. D651 Tensile Strength of Molded Electrical Insulating Materials, Test Method

j. D695 Compression Properties of Rigid Plastics, Test Method

k. D696 Coefficient of Linear Thermal Expansion of Plastics, Test Method

l. D732 Shear Strength of Plastics by Punch Tool, Test Method

m. D790 Flexural Properties of Plastics and Electrical Insulator Materials, Test Method

n. D1149 Rubber Deterioration-Surface Ozone Cracking in a Chamber, Test Method

o. D2303 Liquid-Contaminant, Inclined-Plane Tracking and Erosion of Insulating Materials, Test Method

p. G21 Determining Resistance of Synthetic Polymeric Materials to Fungi, Practice


a. HV1 High-Voltage Insulators

b. PH20 Galvanized Ferrous Insulator Clevises

B. Factory Quality Control: Factory tests shall be made as required by these specifications and the referenced standards. Test reports shall be submitted as detailed herein.

1.3 SUBMITTALS

A. The Contractor shall submit Shop Drawings to HRT for review and approval prior to insulator manufacture, showing details and dimensions of the insulating and metal parts, describing the material composing the various parts, together with technical, mechanical and electrical characteristics and performance data.

B. The Contractor shall prepare and submit an insulator device (assembly) loading table with calculations to indicate the maximum design loading occurring at each insulator location and the type of insulator to be applied at each location.
C. The Contractor shall submit to Houston Metro for review and approval details of the tests proposed for each insulator and the procedures and forms to be used during tests and inspection.

D. Certification:

1. The Contractor shall provide certificates of compliance for the following:
   a. Steel analysis
   b. Hot dip galvanizing
   c. Adhesive materials
   d. Insulator materials
   e. In-service performance record of proposed insulators.
   f. Certified Quality Control Procedures used in the manufacturing process.

E. Data to be furnished by the Contractor, prior to insulator installation:

1. A complete set of assembly, component and detail drawings showing dimensions, weights and the form and fit functions of items.
2. Storage, handling and installation instructions.
3. Details of any specifications for materials included in the insulator assembly which are not covered in this specification.

F. HRT shall be informed at least two (2) weeks in advance of the date on which insulators will be ready for inspection and tests.

G. The Contractor shall submit samples of each type of insulator to be used on the project.

H. The insulators shall be virtually maintenance free. If the manufacturer/supplier recommends specific maintenance procedures and service data, they shall be submitted/approved without exception, prior to the supply of all insulators.
1.4 DELIVERY, STORAGE AND HANDLING

A. The Contractor shall ensure that all materials furnished are suitably packaged and protected against damage during delivery and transportation.

B. The Contractor shall store all products in accordance with the manufacturer's instructions, to ensure that all material is protected from damage and exposure.

C. The Contractor shall handle and otherwise use the insulators in accordance with the manufacturer's instructions so as to ensure that the products are not damaged or misused prior to or during installation.

D. Any damage to the insulators shall be the Contractor's responsibility and all repairs and replacements shall be accomplished by the Contractor in accordance with the manufacturer's instructions.

1.5 WARRANTY

A. The insulators shall have a minimum in-service life expectancy of 30 years under operating conditions.

B. The insulators shall be unconditionally guaranteed in writing by the manufacturer and/or supplier to be free from operational and manufacturing defects for a period not less than 5 years.

PART II - PRODUCTS

2.1 DESCRIPTION

A. The insulators covered by this specification are for use in the following applications and are to be non-ceramic:

1. OCS System Insulators

   a. Cantilever Pipe Insulators - for the support and insulation of the cantilever pipe/tube frames, mounted to the poles. These shall be manufactured from glass fiber reinforced resin with suitable weather-sheds as shown on the Contract Drawings.
b. Messenger Wire Support, In-Span and Termination Insulators - For the vertical and horizontal support, cut-in and dead ending of the main messenger wire which supports the hangers and contact wire. These shall be manufactured from glass fiber reinforced resin with suitable weather-sheds as shown on the Contract Drawings.

c. Contact Wire in-Span and Termination Insulators - For the horizontal cut-in and dead-ending of the grooved contact wire for the OCS System. These shall be manufactured from glass fiber reinforced resin with suitable weather-sheds as shown on the Contract Drawings.

d. Contact Wire Non-Riding Insulators - For the horizontal insulation of the grooved contact wire as a cut-in tension member used on short span overlaps where uplift may cause the pantograph to hit a normal weather-shed insulator. These shall be manufactured from glass fiber reinforced resin without weather-sheds, as shown on the Contract Drawings.

e. Feeder Termination and Line-Post Insulators - For the 750V DC system feeder wires mounted on the OCS structures serving the OCS conductors above the tracks. These shall be manufactured from glass fiber reinforced resin with suitable weather-sheds, as shown on the Contract Drawings.

f. Head-scan, Cross Span, Aerial Head Guy, Termination and In-Span Insulators - For the horizontal insulation of the head-span and cross span wires. These shall be manufactured from glass fiber reinforced with suitable weather-sheds, as shown on the Contract Drawings.

2.2 NON-CERAMIC INSULATOR MATERIALS

A. The non-ceramic insulators shall be of varying types, dependent upon usage. Non-ceramic insulators with cast composite bodies may incorporate metal threaded inserts. Other non-ceramic insulators will be a unit consisting of a non-metallic rod, weather-sheds as required and end fittings. The rod shall be made of glass fiber or reinforced polymer (silicon, rubber, Teflon or Cycloaliphatic resin), with its fibers running longitudinally through the rod length. The rod may be attached to the end fittings or hardware by a compression sleeve, wedge or adhesive. If adhesive is used, the adhesive shall encapsulate the rod in the end-fitting cavity and shall form a compressive wedge upon loading. Weather-sheds shall, for the expected life of the insulators, protect the rod from the elements and insure the necessary leakage distance.
B. The non-ceramic insulators shall be constructed so as to be a lightweight, compact unit with high-impact strength. Weather-sheds shall be "self-cleaning" and weather resistant to reduce the possibility of ice-bridging between sheds. They shall be of a material that is vandal resistant insofar as being shatter-proof, thereby reducing vandalism damage.

C. The insulator's metal parts shall be made of malleable iron, ductile iron or forged steel and be galvanized in accordance with ASTM A153. Metal parts shall be galvanized prior to assembly to the fiberglass rod or composite material insulator body.

D. All insulator types used shall be capable of withstanding service in an environment which includes exposure to ultraviolet radiation, moisture, surface discharges, ozone, temperature extremes, diesel engine exhaust fumes and a diversity of contaminants such as industrial pollutants.

E. The insulators shall be designed to be capable of maintaining the integrity of the weather-shed material at all component interfaces. The interface between fiberglass rod and weather-shed or composite material body and weather-shed shall, for the life of the insulator, remain void-free and dry. Color shall match Federal Standard 595-A, color number 36293 (luster-less medium gray).

F. The resin-bonded glass fiber rods shall be sound and free from any defects or blemishes which may affect the life and performance of the insulator. It shall be of uniform quality throughout its length.

G. All non-ceramic material shall have a smooth, void-free finish. All adhesive coatings shall be sealed to the fittings to protect them against the ingress of moisture.

H. The design shall be such that stress due to temperature variation and mechanical extension/contraction in any part of the insulator under load and normal handling, shall not lead to deterioration. The materials used shall not cause degradation by chemical interactions.

I. The end fittings attached to the fiberglass rod type insulator shall ensure exact alignment with the rod and correct assembly in respect to each other to avoid torsional stress when the insulator is installed.

J. The insulators shall be so designed that no sparking or arcing shall occur on the surface of the insulator when energized at the maximum design voltage under clean and dry conditions.

K. The insulators shall be designed to suit the various catenaries and assembly arrangements, as shown.
SECTION 17327 - INSULATORS

L. The Contractor may submit non-ceramic insulators of alternative design to HRT for approval. The alternative design shall meet or exceed all electrical, mechanical, dimensional, environmental and other technical characteristics as specified herein and all types shown have a proven in-service service history of not less than 5 years.

2.3 SPECIFIC REQUIREMENTS

A. All insulators shall include the fittings and connections for attachment to the pipe, pole or steelwork, as shown.

B. The insulator shall be suitable for both horizontal and vertical mounting and installation, unless otherwise specified.

C. The skirt or weather-shed of all insulators shall be of sufficient diameter to meet the electrical requirements.

D. The insulators shall be formed to fit the specified conductors as shown on the Contract Drawings.

2.4 TECHNICAL CHARACTERISTICS AND DIMENSIONS

A. Technical characteristics of the insulators shall be as shown and indicated herein.

B. Insulator Characteristics.

1. Nominal Voltage: 750 V DC
2. Insulation class: 2 kV
3. BIL: 3.7 kV AC, RMS
4. Leakage Distance: 1.88" (min)
5. Dry Flashover: 35 kV
6. Wet Flashover: 18 kV
2.5 MARKING

A. Each insulator shall bear the manufacturer's name or trademark and year of manufacture, clearly and permanently imprinted or attached without leaving any irregularity that would affect the electrical and mechanical performance of the insulator.

2.6 PRODUCTION TESTS AND FABRICATION

The following tests shall be performed in accordance with ANSI C29.1:

A. Visual and Dimension Test:
   1. The entire surface shall be smooth and free from defects.
   2. If adhesives are used, the insulator shall be inspected to see that the fillet of adhesive provides a complete seal between the coating and end fitting.
   3. The insulator shall be inspected to verify that both end fittings are in line after being assembled on the rod.
   4. The insulator shall be in accordance with approved shop drawings and these specifications.

B. Routine Flashover: A sampling of not less than 5 percent of each type of insulators shall be subjected to a flashover test in accordance with ANSI C29.1. For this test, an electrode shall be placed at each side of and adjacent to, the non-ceramic barrier. Should any test specimen fail, all insulators in the production batch of that specimen are subject to rejection. Alternatively, each insulator in the batch may be tested. Any insulators that puncture will be cause to have the insulator design rejected.

C. Proof Test: All insulators shall be subject to a mechanical strength proof test. The insulators shall be tested at room temperature for ten seconds to 120 percent of the designed tensile, compressive or bending load. Failure shall constitute rejection.
SECTION 17327 - INSULATORS

PART III - EXECUTION

3.1 INSTALLATION

A. The insulators shall be installed in accordance with the manufacturer's instructions, as shown on the Contract Drawings and as specified in Section 17305.

B. All tests shall be completed by the Contractor/Supplier, with all test reports subsequently submitted and accepted by HRT prior to shipment of any insulators to the jobsite.

END OF SECTION
SECTION 17331 – TENSIONING DEVICES

SECTION 17331

TENSIONING DEVICES

PART I - GENERAL

1.1 SUMMARY

A. Description:

1. This Section covers the design, manufacture, supply and installation of auto tensioning devices for the Overhead Contact System (OCS), as shown on the Contract Drawings and specified herein.

2. The Balance Weight Anchor (BWA) assembly automatically regulates the tension of the Low Profile Simple Catenary Auto Tensioned (LPSCAT) and Full Profile Simple Catenary System Auto Tensioned (FPSCAT) style system, by compensating for variations in conductor lengths resulting from changes in temperature due to ambient, solar and electrical heating variations. The weight stack shall be installed inside non-tapered tubular poles only. For a full wire run tension length, a Mid-Point Anchor (MPA) assembly is typically located approximately one-half the distance between the termination ends (where the BWA’s are located) and serves to secure the messenger wire and contact wire from along-track movement at this central point. This effectively divides the full wire run length into two (2) “half-tension” lengths between the MPA and the BWA’s at each end. In addition, half-tension length wire runs are utilized where BWA’s are located at one termination end and Fixed Termination Anchors (FTA’s) are positioned at the other wire run termination. Half tension runs of this configuration do not use a MPA assembly.

B. Related Sections:

1. 17305 - Design and Installation Requirements
2. 17313 - Metal Poles
3. 17323 - Stainless Steel Wire Rope, Strand and Rod
4. 17327 - Insulators
5. 17333 - Fittings and Hardware
6. 17341 - Uninsulated Conductors and Cables
1.2 REFERENCES

A. Pertinent provisions of the following standards shall apply to the work of this Section, except as they may be modified herein and are hereby made a part of this Section to the extent required.

   a. A27 Mild to Medium-Strength Carbon Steel Castings
   b. A36 Structural Steel
   c. A47 Malleable Iron Castings
   d. A123 Zinc Coating on Products Fabricated from Rolled, Pressed and Forged Steel-Shaped Plates, Bars and Strips
   e. A153 Zinc Coating (Hot Dip) on Iron and Steel Hardware
   f. A167 Stainless and Heat-Resisting Chromium Nickel Steel Plate and Strip
   g. A307 Carbon Steel Externally and Internally-Threaded Standard Fasteners
   h. A386 Zinc Coating (Hot Dip) on Assembled Steel Products
   i. A518 Corrosion-Resistant High-Silicon Cast Iron
   j. A536 Ductile Iron Castings
   k. A668 Steel Forgings, Carbon and Alloy for General Industrial Use
   l. A711 Carbon and Alloy Steel Blooms, Billets and Slabs for Forging

1.3 SUBMITTALS

A. The Contractor shall furnish the following for approval:

1. A complete set of Shop Drawings showing the BWA unit assembly, all components and a bill of material giving dimensions, weights and related design and product data. Each BWA assembly shall be configured for the exact OCS run and tension length involved. Appropriate shop drawing and site-specific installation charts shall be provided for each BWA unit supplied.
2. List of special tools, required for the BWA assemblies and installation of a single unit each.

B. The supplier's certificate of compliance shall accompany each shipment of a BWA Tensioner assembly. As a minimum, it shall contain the:

1. Product Name
2. Drawing Number and revision or date
3. Serial Numbers (if required)
4. Quantity
5. Purchase Order Number
6. List of specifications to which the product was produced
7. Supplier's name and address
8. Signature and title of recognized quality authority

C. All test reports shall be submitted to the Engineer for approval.

D. Operation and maintenance data for BWA's and MPA's shall be provided, in accordance with Section 17363.

1.4 DELIVERY, STORAGE and HANDLING:

A. OCS balance weight anchor assemblies and mid-point anchor assemblies shall be packaged in a manner to allow stacking and outdoor storage until installation with no harmful effects.

PART II - PRODUCTS

2.1 BWA PERFORMANCE REQUIREMENTS

A. The BWA assembly shall maintain constant tension in the conductors to compensate for changes in ambient, solar or current heating temperatures. Changes in the lengths of conductors shall be compensated for by an equivalent change in stroke length of the unit. Temperature stop devices shall be incorporated into the unit such that vertical movement of the weights is eliminated due to OCS behavior at conditions below 30° F (without ice) and above 110° F.
B. The BWA assembly shall operate at a nominal pulley ratio of approximately 3:1 and within the range of 2.8:1 to 3.2:1.

C. The BWA assembly shall have pulleys suitable for the wire rope types used and shall be equipped with self-lubricated, weatherproof bearings rated for outdoor (exposed) use in the Houston, Texas environment (described in Section 17301). The bearings shall be sealed to prevent the ingress of moisture or other contaminants and the loss of lubricant (if applicable).

D. The BWA assembly shall operate freely under all climatic conditions within the limits specified and shall function freely when a weight differential of +/- 25 lbs. is applied to the balance weight stack.

E. Balance weights shall typically be fabricated of cast iron, with a vandal-proof assembly. As alternatives, concrete or lead weights may be proposed for use by the Contractor, subject to Engineer review and approval.

F. Weight sets may be either one casting or made up from individual castings. If individual castings are used they shall be of an interlocking design to prevent slippage. The assembled stack of weights shall be cylindrical in shape to suit the available space within the inside diameter of the tubular pole and as compact as possible. Maximum weight for an individual casting shall be 60 lbs.

G. Tolerance on the complete balance weight stack shall be -0 lbs. +50 lbs.

H. Weights shall be compact allowing for the required vertical movements within the interior space provided by the tubular pole. Roller guides on the stack assembly shall be used to minimize the weight stack friction with the interior pole surface.

I. The BWA assembly shall have a minimum design life of 30 years and shall not normally require preventative maintenance or inspection at intervals of less than 12 months. The design shall permit access to the weight stack during installation and subsequent maintenance.

J. Assemblies and component parts shall be designed for ease of maintenance, replacement, assembly and disassembly, which shall be accomplished with a minimum of special tools. Component parts shall be properly identified for this purpose. All special tools required to service and maintain the balance weight assemblies shall be provided by the Contractor.

K. The BWA assembly shall incorporate provisions for adjustment due to wire elongation (stretch).
L. All materials and the unit design shall have been proven by the manufacturer's experience to be suitable for the purpose for which they are intended. They shall be suitable for the loads and climatic conditions existing in the project.

M. All external ferrous parts shall be stainless steel or hot-dip galvanized in accordance with the appropriate ASTM specification. Any ferrous parts which are not stainless steel shall be hot-dipped galvanized or shall be painted with an approved epoxy coating with color to match ANSI #61, light gray.

N. Each BWA tensioning device shall bear the manufacturer's name or trademark and year of manufacture clearly and permanently imprinted.

2.2 TESTING

A. The BWA and MPA assemblies shall be inspected and tested to ensure that they satisfy the Contract requirements, including dimensional accuracy and compatibility with mating components. A test report certifying these requirements shall be submitted to the Engineer.

PART III - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. The BWA and MPA assemblies shall be installed as shown on the Contract Drawings and as specified in Section 17305. All wire rope shall be non-rotational stainless steel.

B. The MPA assembly for each wire run must be fully installed prior to the installation of the respective BWA assemblies.

C. Adjustment and testing of the BWA device shall be in conformance with the manufacturer's instruction manuals.

END OF SECTION
SECTION 17333 – FITTINGS AND HARDWARE

SECTION 17333
FITTINGS AND HARDWARE

PART I - GENERAL

1.1 SUMMARY

A. Description:

1. This Section covers the design, manufacture, supply and installation of ferrous and non-ferrous metal components, line material, hardware and fittings for the Overhead Contact System (OCS), as shown on the Contract Drawings and specified herein. The work includes but is not limited to the following:

a. Hanger Assemblies
b. Wire Cross Assemblies
c. Wire Splices
d. Clevis-Clevis Fittings
e. Wire Terminations
f. Parallel Wire Clamps
f. Nuts, Bolts, Washers and Cotter Pins
g. Messenger Wire Dead Ends
h. Links and Eyebolts
i. Messenger and Trolley Wire Terminations and Turnbuckles
j. Double Clevis End Fittings
k. Thimbles
l. Wire Sleeves
m. Messenger Suspension Clamps and Span Wire Supports
n. Span Wire Clamps
o. Wire Connectors
p. Span Wire Adjustable Straps
q. Strain Clamps
r. Knuckle Assemblies and Wire Spacers
s. Trunion Clamps
t. Pole Bands

B Related Sections:

1. 17305 - OCS - Design and Installation Requirements
2. 17313 - OCS - Metal Poles
3. 17314 - Pole Painting
4. 17315 - Signage
5. 17319 - Supporting Devices
6. 17321 - Galvanized Steel Wire and Wire Rope
7. 17323 - Stainless Steel Wire Rope, Strand and Rod
8. 17327 - Insulators
9. 17329 - Section Insulators
10. 17331 - Tensioning Devices
11. 17341 - Uninsulated Conductors and Cables

1.2 REFERENCES:

A. Codes and Standards: Pertinent provisions of the following listed standards shall apply to the work of this section, except as they may be modified herein and are hereby made a part of this Specification to the extent required.

1. Ferrous Metals:
SECTION 17333 – FITTINGS AND HARDWARE

1. Ferrous Metals:
   i. A27 - Mild to Medium-Strength Carbon-Steel Castings
   ii. A47 - Malleable Iron Castings
   iii. A153 - Zinc coating (Hot-Dip) on Iron and Steel Hardware
   iv. A167 - Stainless and Heat-Resisting Steel
   v. A518 - Corrosion-Resistant High Silicon Cast Iron
   vi. A536 - Ductile Iron Castings
   vii. A668 - Steel Forgings, Carbon and Alloy, for General Industrial Use
   viii. A711 - Carbon and Alloy Steel Blooms, Billets and Slabs for Forgings
   ix. A747 - Steel Castings, Stainless, Precipitation Hardening

2. Non-Ferrous Metals:
      i. B26 - Specification for Aluminum-Alloy Sand Castings
      ii. B148 - Aluminum-Bronze Sand Castings
      iii. B179 - Aluminum Alloys in Ingot Form for Sand Castings, Permanent Mold Castings and Die Castings
      iv. B248 - General Requirements for Wrought Copper and Copper-Alloy Plate, Sheet, Strips and Rolled Bar
      v. B249 - General Requirements for Wrought Copper and Copper-Alloy Rod, Bar and Shapes
      vi. B557 - Methods of Tension Testing Wrought and Cast Iron Aluminum and Magnesium - Alloy
      vii. B584 - Copper Alloy Sand Castings for General Applications
      viii. B686 - Specification for Aluminum Alloy Castings - High Strength
1.3 QUALITY ASSURANCE

A. For tension tests, a minimum of three (3) test bars shall be poured from each lot of metal.

B. For chemical analysis each lot of castings shall be analyzed for conformance with the chemical composition specified in the referenced ASTM standards.

C. A lot shall consist of all castings produced from one furnace melt.

1.4 SUBMITTALS

A. Shop Drawings: The Contractor shall submit Shop Drawings for all OCS hardware and components for approval by the Engineer prior to manufacture, showing details and dimensions and giving designations of the materials comprising the various components together with technical, mechanical and electrical data as appropriate.

B. Samples of major assemblies and components shall be submitted to the Engineer for approval, as listed below, as well as any others that may be requested by the Engineer:

1. Messenger wire saddles
2. Contact wire clamps
3. Hanger assemblies
4. Wire splices
5. Messenger suspension clamps
6. Messenger span wire supports
7. Messenger and contact wire terminations
8. Parallel wire clamps

C. Operational (installation) and maintenance data shall be provided for all components addressed in this Section, in accordance with Section 17363.
1.5 DELIVERY, STORAGE AND HANDLING

A. The identification mark of the manufacturer or foundry and the pattern numbers assigned by the supplier shall be cast into all castings. Marks and numbers shall be readable size and in such a position that they will not affect their electrical or mechanical performance.

B. Fittings and hardware shall be packed in accordance with the best commercial practice, adequate to ensure acceptance and safe delivery.

C. All shipping boxes, bags, or crates shall be properly marked showing the contents of each. If different materials are packaged in a box, bag or crate all items of a kind should be boxed, bagged or crated and properly marked or tagged prior to placement in the shipping vessel.

D. OCS fittings and hardware shall be packaged in a manner to allow stacking and outdoor storage until installation with no harmful effects.

PART II -PRODUCTS

2.1 MATERIALS

A. Material for hardware and fittings shall comply with the applicable referenced standards. Substitutions will be considered and approved if the requirements of the Contract Documents are satisfied. The Contractor shall be responsible for the complete form and fit of all OCS components and hardware which make up the OCS assemblies and equipment, as shown on the Contract Drawings.

B. All materials and components used in the OCS assemblies shall be of sufficient strength and durability to withstand the calculated loads with addition of a minimum factor of safety of 2.5. The factor of safety shall be greater than 2.5 where indicated in these contract documents and where recommended by the manufacturer.

2.2 METAL CHARACTERISTICS

A. Malleable Iron: Fittings or components made of malleable iron shall be grade 32510 or better and shall conform to ASTM A47. All components and fittings shall be galvanized in accordance with ASTM A153.

B. Forged Steel: Material for forged steel shall comply with ASTM A711 or A668. All components and fittings shall be galvanized in accordance with ASTM A153.
SECTION 17333 – FITTINGS AND HARDWARE

C. Ductile Iron: Fittings or components requiring high yield strength shall be of ductile iron, grade 60.40.18 or better and shall conform to ASTM A536. All fittings and components shall be galvanized in accordance with ASTM A153.

D. Stainless Steel: Stainless Steel hardware shall conform to ASTM A747.

E. Non-Ferrous Metals: Copper alloys for fittings and components shall conform to ASTM B584 and B148.

F. Copper: All copper components shall conform to ASTM B248 or B249.

G. Aluminum components shall conform to ASTM B26, B557 and B686.

H. All cotter pins, roll pins, spring clips and hitch pins, shall be made out of stainless steel.

2.3 MISCELLANEOUS CHARACTERISTICS

A. Neoprene Isolation Sleeve for the Messenger Wire to Hanger Loop Clamp Pad for the Short, Insulated Hanger Assemblies: A synthetic rubber sheet material, Neoprene ASTM type CR (or approved alternate such as Hypolon or EPDM), industrial grade that is non-conducting and flexible, with excellent UV and ozone resistance characteristics, Shore-A hardness rating of 70 +/- 5 after 10 seconds, exhibit good abrasion resistance, stable electrical characteristics, excellent toughness, a self-extinguishing non-propagating material suitable to a harsh outdoor environment, capable of consistently providing a 900 VDC insulation level in the new hanger assembly. The exact sleeve material proposed shall be fully described by a detailed shop drawing submittal, including all dimensions, itemized material characteristics (technical and electrical) and laboratory test performance data.

B. Insulated Thimble for Flexible Wire Rope Hanger Assembly: The Insulated thimble shall be a non-metallic, industrial grade nylon material (or approved equal). Material shall be rigid and not demonstrate any high temperature softening or flaring at 130°F. Material shall have excellent toughness and suitable to a harsh outdoor environment, UV, sunlight and ozone resistant and capable of providing a 900 VDC insulation level in the new hanger assembly. A shop drawing shall be submitted, including itemized material characteristics (technical and electrical) and laboratory test performance data.

2.4 FABRICATION

A. The designated metals shall be produced by an approved method that will meet the requirements of this Section.
B. Castings shall be of uniform quality and shall be made in such a manner that the material of the casting conforms to the chemical and mechanical properties prescribed in the referenced ASTM standards.

2.4 WORKMANSHIP, FINISH and APPEARANCE

A. The castings shall be free of adhering sand, voids, cracks, surface porosity and non-uniform dimensions.

B. The Contractor shall be responsible for the form, function and fit, including the dimensional accuracy of all assembly and equipment fittings and hardware.

C. Repairs shall be permitted only to the extent allowed by the referenced ASTM standards. If welding or repair of a greater magnitude is required, the Contractor shall obtain approval prior to proceeding.

PART III - EXECUTION

3.1 INSTALLATION REQUIREMENTS

A. Installation requirements for fittings and hardware shall be in accordance with the manufacturer's recommendations and as shown on the Contract Drawings and as specified in Section 17305.

3.2 COMPONENT PERFORMANCE AND USABILITY

A. All fittings and hardware used for OCS assemblies shall be selected and made such that they can be reused after removal (except for pole banding and compression sleeves and caps).

B. All fittings and hardware shall be designed for easy interface with the other components of the electrification system.

C. All fittings and hardware shall be designed and installed to provide a fully functional, homogenous OCS hardware and assembly arrangement.

D. Components and assemblies shall be designed such that all fastenings and adjustments are accomplished with the same dimensional standards or tools (i.e., Metric or American standards shall be consistently used on the same part).

END OF SECTION