



2021-2022 Review Cycle
General Requirements and
Standard Construction Specifications
Redlines



July 1, 2022

SECTION 01145

USE OF PREMISES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. General use of the site including properties inside and outside of rights-of-way, work affecting road, ramps, streets and driveways and notification to adjacent occupants.

1.02 RIGHTS-OF-WAY

- A. Confine access, and operations and storage areas to rights-of-way provided by the City as stipulated in Document 00700 - General Conditions; trespassing on abutting lands or other lands in the area is not allowed.
- B. Make arrangements, at no cost to the City, for temporary use of private properties. ~~Contractor and Surety shall indemnify and hold harmless the City against claims or demands arising from such use of properties outside of rights-of-way.~~ Submit a copy of agreements between private property owners and Contractor prior to use of the area. Agreements between private property owners and Contractor shall be notarized or bear the signatures of two witnesses.
- C. Obtain written permission from City of Houston Parks and Recreation Department for storage of materials on esplanades and other areas within rights-of-way under that department's jurisdiction. Submit copies of written permission prior to use of the area.
- D. Restrict total length of distributed materials along the route of construction to 1,000 linear feet unless otherwise approved in writing by City Engineer.

1.03 PROPERTIES OUTSIDE OF RIGHTS-OF-WAY

- A. Do not alter the condition of properties adjacent to and along rights-of-way.
- B. Do not use ways, means, methods, techniques, sequences, or procedures that result in damage to properties or improvements.
- C. Restore damaged properties outside of rights-of-ways at no cost to the city

1.04 USE OF SITE

- A. Obtain approvals from Project Manager and governing authorities prior to impeding or closing public roads and streets. Do not close more than two consecutive intersections at one time.

- B. Notify Project Manager and Houston Public Works ~~and Engineering~~ Traffic Management ~~Branch~~ at least five working days prior to closing a street or street crossing. Obtain permits for street closures in advance.
- C. Maintain 10-foot-wide minimum access lanes for emergency vehicles including access to fire hydrants.
- D. Avoid obstructing drainage ditches or inlets. When obstruction is unavoidable due to requirements of the Work, provide grading and temporary drainage structures to maintain unimpeded flow.
- E. Locate and protect private lawn sprinkler systems that may exist within the site. Repair or replace damaged systems to condition existing at start of the Work, or better. Test irrigation system prior to construction.
- F. Conform to daily clean-up requirements of Article 3 of Document 00700 - General Conditions.
- G. Beware of overhead power lines existing in area and in close proximity of the Project. When 10 feet of clearance between energized overhead power line and construction-related activity cannot be maintained, request Center Point Energy (CPE) de-energize or move conflicting overhead power line. Contact CPE representatives at (713) 207-2222. Schedule, coordinate and pay costs associated with de-energizing or moving conflicting overhead power lines. When there is no separate pay item for this effort, include these costs in various items of bid that make such work necessary.

~~G-H.~~ Maintain access to all buildings, driveways and parking lots throughout the Project.

1.05 NOTIFICATION TO ADJACENT OCCUPANTS

- A. Notify individual occupants in areas to be ~~effected~~ affected by the Work of proposed construction and time schedule. Notify not less than 72 hours or more than two weeks prior to work performed within 200 feet of homes or businesses. Follow form and content of sample door hanger provided by Project Manager.
- B. Include in notification nature of the Work, and names and telephone numbers of two company representatives for resident contact available on 24-hour call.
- C. Submit proposed notification to Project Manager for approval. Consider ethnicity of the neighborhood where English is not the dominant language. Provide notice in an understandable language.
- D. In regard to notifications on all small-diameter water lines (as defined in City of Houston Specification Section 02512 - Water Tap and Service Line Installation), the Contractor must perform all customer notifications and complete a Notice of Customer Communication form provided by the Project Manager that such notice has been given 48-hours in advance of any water disruptions. Notification must also include the approximate duration of planned service outages. The City of Houston Inspector must

have the completed Notification of Customer Communication form before the commencement of valve assisted work. Follow the form and content of sample door hanger provided by Project Manager.

1.06 PUBLIC, TEMPORARY, AND CONSTRUCTION ROADS AND RAMPS

- A. Construct and maintain temporary detours, ramps, and roads to provide for normal public traffic flow when it is necessary to close public roads or streets.
- B. Provide mats or other means to prevent overloading or damage to existing roadways from tracked equipment, large tandem axle trucks or equipment that will damage the existing roadway surfaces.
- C. Construct and maintain access roads and parking areas as specified in Section 01504 - Temporary Facilities and Controls.

1.07 EXCAVATION IN STREETS AND DRIVEWAYS

- A. Avoid hindering or inconveniencing public travel on streets or intersecting alleys for more than two blocks at any one time, except by permission of City Engineer.
- B. Obtain Traffic Management ~~Branch~~ and City Engineer's approval when nature of the Work requires closure of an entire street. Permits required for street closure are Contractor's responsibility. Avoid unnecessary inconvenience to abutting property owners.
- C. Remove surplus materials and debris and open each block for public use, as work in that block is complete.
- D. Acceptance of any portion of the Work will not be based on return of street to public use.
- E. Avoid obstructing driveways or entrances to private property.
- F. Provide temporary crossings or complete excavation and backfill in one continuous operation to minimize duration of obstruction when excavation is required across drives or entrances.
- G. Provide barricades and signs in accordance with Section VI of the State of Texas Manual on Uniform Traffic Control Devices.

1.08 TRAFFIC CONTROL

- A. Comply with traffic regulation as specified in Section 01555 - Traffic Control and Regulation.

1.09 SURFACE RESTORATION

- A. Restore the site including landscaping to the condition existing before construction, or better.
- B. Repair paved areas per the requirements of Section 02951 - Pavement Repair and ~~restoration~~ Restoration.
- C. Repair damaged turf areas, level with bank run sand conforming to Section 02317 - Excavation and Backfill for Utilities, or topsoil conforming to Section 02911 - Topsoil, and re-sod in accordance with Section 02922 - Sodding. Water and level newly sodded areas with adjoining turf using appropriate steel wheel rollers for sodding. Do not use spot sodding or sprigging.

1.10 LIMITS OF CONSTRUCTION

- A. Confine operations to lands within construction work limits shown on Drawings. Unless otherwise noted on Drawings adhere to the following:
 - 1. Where utility alignment is within esplanade, and construction limits are shown on Drawings to extend to edge of esplanade, keep equipment, materials, stockpiles a minimum of five feet from back of curb.
 - 2. Where construction limits shown on Drawings extend to property line, keep sidewalks free of equipment, materials, and stockpiles.

1.11 EQUIPMENT AND MATERIAL SALVAGE

- A. Upon completion of the Work, carefully remove salvageable equipment and material. Deliver them to City of Houston as directed by Project Manager. Dispose of equipment offsite at no additional cost to the City when Project Manager deems equipment unfit for further use.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION - Not Used

END OF SECTION

SECTION 01340

SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Methods, schedules, and processes to be followed for Shop Drawings, Product Data and Sample submittals.

1.02 REQUIREMENT

- A. Submit Shop Drawings, Product Data and Samples as required by Document 00700 - General Conditions and Specification sections, using procedures specified in Section 01330 - Submittal Procedures and the requirements of this Section.
- B. Shop Drawings, Product Data and Samples are not considered Contract documents.

1.03 SHOP DRAWING/SUBMITTAL SCHEDULE

- A. Submit a separate Shop Drawing submittal schedule at same time the Construction Schedule is submitted. List Products for which Shop Drawings and other submittals are required in the order that they appear in Specifications. Include Product Data and Sample submittals in the schedule. Payment Applications or Certificates for Payment will not be processed until Project Manager has approved the Shop Drawing submittal schedule.

1.04 SHOP DRAWINGS

- A. Submit Shop Drawings and Product Data through the City's electronic project management system. If the City's project management system cannot accommodate the file, submit the Shop Drawings and Product Data using an alternate method approved by the Project Manager.~~Submit a minimum of seven sets of Shop Drawings and Product Data in a form and quality suitable for microfilming. Review and sign Shop Drawings indicating compliance with the Contract.~~
- B. Place Contractor's Stamp on each drawing as described in Section 01330 - Submittal Procedures.
- C. Show the following accurately and distinctly:
 - 1. Field and erection dimensions;
 - 2. Arrangement and section views;
 - 3. Relation to adjacent materials or structure, including complete information for

making connections between the Work and work under other contracts;

4. Types of Products and finishes;
 5. Parts list and descriptions;
 6. Assembly drawings of equipment components and accessories showing respective positions and relationships to the complete equipment package;
 7. Identify details by referencing drawing sheet and detail numbers, schedule or room numbers as shown on the Contract drawings, where necessary for clarity.
- D. Scale drawings to provide a true representation of the specific equipment or item Furnished.
- E. Coordinate and submit components, necessary for Project Manager to adequately review submittal, as a complete package. Reproduction of the Drawings for use in Shop Drawings is not allowed.
- F. For major changes to original documents, submit Computer-Aided Design (CAD) drawings on a media acceptable to Project Manager.

1.05 PRODUCT DATA

- A. Submit Product Data for review as required in Specifications.
- B. Place Contractor's stamp, on each data item submitted, as described in Section 01330 - Submittal Procedures.
- C. Mark each copy to identify applicable Products, models, and options to be used in the Work. Where required by Specifications, supplement manufacturers' standard data to provide information unique to the Work.
- D. Give manufacturers, trade name, model or catalog designation and applicable reference standard for Products specified only by reference standards.
- E. Pre-approved and ~~Pre-qualified~~Approved Products:-
1. For "pre-approved", "~~pre-qualified~~" and "~~approved~~" Products named in the City's ~~standard-pre-approved~~ products list, provide an appropriate list designation, as described in Section 01630 - Product Substitution Procedures, within 30 days after Notice to Proceed.
 2. For Products proposed as alternates to "approved" products, provide information required to demonstrate that the proposed Products meet the level of quality and performance criteria of the "approved" product.

1.06 SAMPLES

- A. Submit Samples for review as required by Specifications. Have Samples reviewed and signed by a Registered Professional.
- B. Place Contractor's stamp on each Sample or firmly attach a sheet of paper with Contractor's stamp, as described in Section 01330 - Submittal Procedures.
- C. Submit the number of Samples specified in Specifications; Project Manager will retain one.
- D. Reviewed Samples that may be used in the Work are identified in Specifications.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION - Not Used

END OF SECTION

SECTION 01422

REFERENCE STANDARDS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Section includes general quality assurance as related to ~~Reference-reference Standards-standards~~ and a list of references.

1.02 QUALITY ASSURANCE

- A. For Products or workmanship specified by association, trade, or Federal ~~Standardsstandards~~, comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.
- B. Conform to reference standard by date of issue current on the date as stated in the General Conditions.
- C. Request clarification from Project Manager before proceeding should specified reference standards conflict with Contract documents.

1.03 SCHEDULE OF REFERENCES

- A. AASHTO American Association of State Highway and Transportation Officials
~~444 North Capitol Street, N.W. Washington, DC 20001~~
- B. ACI American Concrete Institute
~~P.O. Box 9094~~
~~Farmington Hills, MI 48333-9094~~
- C. AGC Associated General Contractors of America
~~333 John Carlyle Street~~
~~Alexandria, VA 22314~~
- ~~D. AI Asphalt Institute Research Park Drive~~
~~E.D. P.O. Box 14052 Lexington, KY 40512~~
- ~~F.E. AITC American Institute of Timber Construction~~
~~7012 S. Revere Parkway, Suite 140~~
~~Englewood, CO 80112~~
- ~~G.F. AISC American Institute of Steel Construction~~
~~One East Wacker Dr.~~
~~Chicago, IL 60601~~

H.G.	AISI	American Iron and Steel Institute 1101 17th Street NW, Suite 1300 Washington, DC 20036
H.	ASME	American Society of Mechanical Engineers Three Park Avenue New York, NY 10016
I.	AMPP	<u>The Association for Materials Protection and Performance</u>
I.J.	ANSI	American National Standards Institute 1819 L Street NW Sixth Floor Washington, D.C. 20036
J.K.	APA	American Engineered Plywood Wood Association Box 11700 Tacoma, WA 98411
K.L.	API	American Petroleum Institute 1220 L Street, N.W. Washington, DC 20005
L.M.	AREMA	American Railway Engineering and Maintenance-of-Way- Association 8201 Corporate Drive, Suite 1125 Landover, Maryland 20785
M.N.	ASTM	American Society for Testing and Materials <u>International</u> 100 Barr Harbor Drive West Conshohocken, PA 19428
N.O.	AWPA	American Wood- Preservers' Protection Association P.O. Box 5690 Granbury, TX 76049
O.P.	AWS	American Welding Society 550 NW 42nd Avenue Miami, FL 33126
P.Q.	AWWA	American Water Works Association 6666 West Quincy Avenue Denver, CO 80235
Q.R.	COH	City of Houston P.O. Box 1562 Houston, TX 77251-1562
S.	CLFMI	Chain Link Fence Manufacturers Institute

~~9891 Broken Land Parkway, Suite 300
Columbia, MD 21046~~

T. CRSI Concrete Reinforcing Steel Institute
~~933 Plum Grove Road Schaumburg, IL 60173 4758~~

U. EJMA Expansion Joint Manufacturers Association
~~25 North Broadway
Tarrytown, NY 10591~~

~~R.V. FS Federal Standardization Documents
General Services Administration
Specifications Unit (WFSIS)
7th and D Streets, S.W.
Washington, DC 20406~~

~~S.W. ICEA Insulated Cable Engineers Association
P.O. Box 440
S. Yarmouth, MA 02664~~

~~T.X. IEEE Institute of Electrical and Electronics Engineers
445 Hoes Lane
P.O. Box 440
Piscataway, NJ 08855 459~~

~~U.Y. ISA International Society of Arboriculture
P.O. Box 3129
Champaign, IL 61826 3129~~

Z. MIL Military Specifications

~~General Services Administration
Specifications Unit (WFSIS)
7th and D Streets, S.W.
Washington, DC 20406~~

AA. NACE International National Association of Corrosion Engineers

~~1440 South Creek Drive
Houston, TX 77084 4906~~

~~V.BB. NEMA National Electrical Manufacturers' Association
1300 North 17th Street, Suite 1847
Rosslyn, VA 22209~~

~~W.CC. NFPA National Fire Protection Association
1 Batterymarch Park
P.O. Box 9101
Quincy, MA 02269 9101~~

X.DD.	OSHA	Occupational Safety <u>and</u> Health Administration U.S. Department of Labor Office of Public Affairs Room N3647 Washington, DC 20210
Y.EE.	PCA	Portland Cement Association 5420 Old Orchard Road Skokie, IL 60077 1083
Z.FF.	PCI	<u>Precast</u> /Prestressed Concrete Institute 209 W. Jackson Blvd. Chicago, IL 60606
<u>GG.</u>	<u>PPI</u>	<u>Plastic Pipes Institute</u>
AA.HH.	SDI	Steel Deck Institute P.O. Box 25 Fox River Grove, IL 60021
BB.	SSPC	Society for Protective Coatings (Steel Structures
CC.	Painting Council)	40 24th Street, Sixth Floor
II.		Pittsburgh, PA 15222
DD.JJ.	TAC	Texas Administrative Code Texas Water Resources Conservation Commission P. O. Box 13087 Library MC 196 Austin, TX 78711 3087
<u>KK.</u>	<u>TxDOT</u>	<u>Texas Department of Transportation</u> <u>125 East 11th Street</u> <u>Austin, TX 78701 2483</u>

~~EE.LL.~~ UL _____ Underwriters' Laboratories, Inc.

_____ ~~333 Pfingston Road~~

_____ ~~Northbrook, IL 60062~~

~~FF.MM.~~ UNI-BELL ~~UNI-BELL-PVC~~ Pipe Association

_____ ~~2655 Villa Creek Drive, Suite 155~~

_____ ~~Dallas, TX 75234~~

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION - Not Used

END OF SECTION

SECTION 01450

CONTRACTOR'S QUALITY CONTROL

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Quality assurance and control of Installation and manufacturers' field services and reports.

1.02 QUALITY ASSURANCE AND CONTROL OF INSTALLATION

- A. Monitor quality control over Suppliers, manufacturers, Products, services, site conditions and workmanship, to produce work of specified quality at no additional cost to the City.
- B. Comply fully with manufacturers' Installation instructions, including each step in sequence.
- C. Request clarification from Project Manager before proceeding when manufacturers' instructions conflict with the Contract.
- D. Comply with specified standards as minimum requirements for the Work except when more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.
- E. Perform the Work by persons qualified to produce a specified level of workmanship.

1.03 REFERENCES

- A. Obtain copies of standards and maintain at job site when required by individual Specification sections.

1.04 MANUFACTURERS' FIELD SERVICES AND REPORTS

- A. When specified in individual Specification sections, or as required by Project Manager, provide Product suppliers' or manufacturers' technical representative to observe the following:

1. -Site conditions;

2. -Conditions of surfaces and Installation;

3. -Quality of workmanship;

4. -Start-up of equipment;

5. -Operator training; and

6. Testing, adjusting and balancing of equipment as applicable ~~and~~ to initiate required operation.

~~A.B.~~ Conform to minimum time requirements for start-up operations and operator training when provided in Specification sections.

~~B.C.~~ At Project Manager's request, submit qualifications of manufacturers' representative to Project Manager 15 days in advance of required representatives' services. Representative is subject to approval by Project Manager.

~~C.D.~~ Manufacturer's representatives shall report observations and site decisions, or instructions given to applicators or installers that are supplemental or contrary to a manufacturer's written instructions. Submit report within 14 days of observation to Project Manager for review.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION - Not Used

END OF SECTION

SECTION 01502

MOBILIZATION

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Mobilization of construction equipment and facilities onto the site.

1.02 MEASUREMENT AND PAYMENT

- A. Unit Price Contracts. If Contract is Unit Price Contract, measurement for mobilization is on a lump sum basis.
- B. Stipulated Price (Lump Sum) Contract. If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.
- C. Mobilization payments will be included in monthly payment estimates upon written application by Contractor subject to the following provisions:
 - 1. Authorization for payment of 50 percent of that portion of Contract Price designated for mobilization will be made upon receipt and approval by Project Manager of the following items, as applicable:
 - a. Safety Program (Document 00700, Paragraph 10.1.1).
 - b. Site Utilization Plan (Section 01145).
 - c. Schedule of Values (Section 01292), if any.
 - d. Initial Construction Photographs (Section 01321), if needed.
 - e. Preliminary Construction Schedule and Billing Forecast (Section 01325).
 - f. Construction Schedule (Section 01325 or Section 01326, as applicable).
 - g. Submittal Schedule (Section 01330).
 - h. Site specific Storm Water Pollution Prevention Plan (SWPPP) and Notice of Intent (NOI) along with storm water application fee (Section 01410), if required.
 - i. Contractor's Quality Control Plan (Section 01450), if required.
 - j. Establishment of a Field Office for Project Manager meeting

requirements of Section 01520 - Temporary Field Office.

- k. Traffic Control Plan (Section 01555), if required.
 - l. Plan for Control of Ground and Surface Water (Section 01578), if required.
 - m. Project Signs Submittal (Section 01580 or Section 01582).
 - n. Trench Safety Program (Section 02260), if required.
 - o. Dewatering plan, when required.
- 2. Authorization for payment of the balance of that portion of Contract Price designated for mobilization will be made upon completion of the Work amounting to five percent of Original Contract Price. The amount of Contract Price designated for mobilization may not be applied in computing whether or not five percent of the Original Contract Price has been obtained.
 - 3. Mobilization payments will be subject to retainage amounts stipulated in Document 00700 – General Conditions.

PART 2 PRODUCTS -Not Used

PART 3 EXECUTION -Not Used

END OF SECTION

SECTION 01582

**BUILD HOUSTON FORWARD
PROJECT IDENTIFICATION SIGNS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Project identification sign description.
- B. Project sign installation.
- C. Maintenance and removal of Project sign.

1.02 DELIVERY AND HANDLING

- A. Contractor to pick-up signs and install at locations dictated in the Drawings unless otherwise specified by Project Manager at pre-construction meeting.

1.03 SUBMITTALS

- A. Submit Shop Drawings under provisions of Section 01330 - Submittal procedures.
- B. The shop drawing should include size of the proposed Aluminum sign plate and the signpost detail applicable for the project.

1.04 MEASUREMENT AND PAYMENT

- A. Payment for this item will be measured by each "Build Houston Forward Identification Sign" installed and maintained at the project site.
- B. Payment for the work performed and material furnished in accordance with this item will be paid for "Build Houston Forward Identification Sign" of the size specified. The price is full compensation for picking up sign from the sign shop, installing and maintaining new signs and hardware, and then returning each sign plate back to the sign shop at the end of the project. cost of associated posts, footings, and miscellaneous mounting hardware will not be paid for directly but is to be included in the unit price bid for installation of each Build Houston Forward project identification sign.

PART 2 PRODUCTS

2.01 SIGN MATERIALS

- A. Structure and Framing: Use new sign materials.

1. Signposts / Tubing:
 - a. Steel post shall conform to the standard specification for hot rolled carbon sheet steel, structural quality, ASTM designation A570, Grade 50. Average minimum yield strength after cold forming is 60,000 psi. The cross section of the post shall be square tube formed steel, carefully rolled to size and shall be welded directly in the corner by high frequency resistance welding or equivalent process and externally scarified to agree with corner radii. Signposts shall be hot dipped galvanized conforming to ASTM A653, G90.
 - b. 24-inch sign: 1 ¾-inch by 1 ¾-inch galvanized square perforated signposts minimum length:
 - 1) Concrete Footing – 140-inch-long post
 - 2) Skid Mounting – 104-inch-long post
 - 3) Pile Driven – 154-inch-long post
 - 4) Surface Mounting – 106-inch-long post
 - c. 48-inch sign: 1 ¾-inch by 1 ¾-inch galvanized square perforated signposts minimum length:
 - 1) Concrete Footing – 125-inch-long post
 - 2) Skid Mounting – 89-inch-long post
 - 3) Pile Driven – 139-inch-long post
 - 4) Surface Mounting – 91-inch-long post
2. Skid Mounted Signs:
 - a. Use for projects with noncontiguous locations where work progresses from one location to another.
 - b. Secure skid structure to withstand a 60 mile-per-hour wind load to the face or back of sign using stakes, straps, or ballast. Contractor shall be responsible for security of signs at each site.
 - c. Where sign supports require the use of weights to keep from turning over, the use of sandbags with dry, cohesionless sand should be used.
 - d. The sandbags shall be tied shut to keep the sand from spilling and to maintain a constant weight.

- e. Rock, concrete, iron, steel, or other solid objects shall not be permitted for use as sign support weights.
 - f. Sandbags should weigh a minimum of 35 lbs. and a maximum of 50 lbs.
 - g. Sandbags shall be made of a durable material that tears upon vehicular impact. Rubber (such as tire inner tubes) shall NOT be used.
 - h. Sandbags shall only be placed along or laid over the base supports of the traffic control device and shall not be suspended above ground level or hung with rope, wire, chains or other fasteners. Sandbags shall be placed along the length of the skids to weigh down the sign support.
 - i. Sandbags shall NOT be placed under the skid and shall not be used to level sign supports placed on slopes.
3. Fasteners:
- a. Galvanized steel.
 - b. Attach sign to posts with 5/16-inch by 3-inch hex head bolts and secure with hex nylon locknut and split lock washers.
 - c. Bolts to connect perforated metal tubes shall be 3/8-inch by 3-inch grade 8.
 - d. Bolts to connect square perforated tubing cross brace on 48-inch sign shall be 3/8-inch by 4 1/2-inch grade 8 bolt.
 - e. Cover hex heads with white reflective film or paint to match sign background.

2.02 FABRICATION

- A. Sign Construction: Construct signs of new materials in accordance with Standard Detail provided at the Pre-construction Conference.
 - 1. Aluminum sign plate, reflective sign sheet, and sign preparation to be performed by City of Houston Sign Shop.
- B. City of Houston Project Manager submit the Sign Intake Form to Build Houston Forward Sign Coordinator 21 days before project Commencement.
- C. Build Houston Forward Sign Coordinator shall provide content, layout, lettering style, lettering size, and colors for fabrication. The Sign Coordinator provides abbreviated project name, convert Construction Start and Completion Dates, produce QR-Code for the sign, and send completed form to City of Houston Sign Shop.
- D. City of Houston Sign Shop will notify the Project Manager to schedule a pickup when the sign is ready for project use.

- E. As notified by the Project Manager, the Contractor shall pick up sign from sign shop, transport to the project site and install the sign per approved sign submittal.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install Project identification signs within seven days after Date of Commencement of the Work.
- B. Sign Placement: Erect signs at locations shown in Drawings unless otherwise designated by Project Manager at pre-construction meeting. Position sign so it is fully visible and readable to the general public.
 - 1. Provide one sign at each end of a linear Project involving paving, overlay, sewer line, storm drainage, or water main construction located in rights-of-ways.
 - 2. Provide one sign for site or building construction Contracts.
 - 3. Provide one sign at each site for Contracts with multiple sites.
 - 4. Sign Relocation: As work progresses, relocate signs if directed by Project Manager in writing. Include cost for one relocation of post-mounted signs in Contract Price. Subsequent relocations, if directed by Project Manager in writing, will be subject to Change Order.
- C. Erect sign level and plumb.
- D. The square end of the post shall not be modified or pointed.
- E. When signpost installation is required over building basements, bridges and cavities, an ASTM A-536 Grade 65-45-12 Ductile Iron surface mounting sign base shall be used. The base shall be connected to the surface with four 0.56-inch diameter holes and 8-inch by ½-inch screws. The neck of the flange shall have inside dimensions of 2.06-inch by 2.06-inch with a thickness of 0.75-inch and be connected to the signpost with hex nylon insert locknuts (NE), Grade 8, yellow zinc plated.
- F. For concrete footing installations:
 - 1. Anchors shall be anchored in a minimum of one cubic foot of class “C” concrete, 34 inches deep, with a 6 inch long, ¾ inch diameter pin inserted through the pre-drilled hole 3 inches from the bottom of the square anchor stub.
 - 2. If mounted on posts in concrete footings stabilize posts to minimize lateral motion.

3. Leave a minimum of 9 feet of post above existing grade for mounting of 24-inch sign, and 8 feet of post above existing grade for mounting 48-inch sign.
- G. Where the pole installation requires surface mounting, an ASTM A-536 Grade 65-45-12 Ductile Iron surface mounting sign base shall be used. The base shall be connected to the surface with four 0.56-inch diameter holes and 8-inch by ½-inch screws. The neck of the flange shall have inside dimensions of 2.06-inch by 2.06-inch with a thickness of 0.75-inch and be connected to the signpost with hex nylon insert locknuts (NE), Grade 8, yellow zinc plated.
- H. If mounted on posts and pile driven, set posts a minimum of 4-feet below grade and stabilize posts to minimize lateral motion.
- I. If mounted on skid mounts:
 1. 24-inch sign – install post into tee section and secure with nut and bolt assembly. Install tee section into base of tee section and secure with nut and bolt assembly.
 2. 48-inch sign – install both posts into tee sections and secure with nut and bolt assembly.

3.02 MAINTENANCE AND REMOVAL

- A. Keep signs and supports clean and neat looking throughout contract duration. Repair deterioration and damage.
- B. Contractor to return sign to City Sign Shop upon project completion.
- C. Completely remove signs, framing, supports, and foundations upon completion of Project. Restore area to a condition equal to or better than before construction.

END OF SECTION

SECTION 01725

FIELD SURVEYING

PART 1 GENERAL

1.01 QUALITY CONTROL

- A. Conform to State of Texas laws for surveys requiring ~~licensed surveyors~~ Registered Professional Land Surveyors (RPLS). Employ a ~~surveyor~~ RPLS acceptable to Project Manager if required by the Contract.

1.02 MEASUREMENT AND PAYMENT

A. UNIT PRICES

- 1. No separate payment will be made for field surveying. Include cost in unit price for related items.

1.03 SUBMITTALS

- A. Conform to requirements of Section 01330 - Submittal Procedures.
- B. Submit name, address, and telephone number of ~~Surveyor~~ RPLS to Project Manager before starting survey work.
- C. Submit documentation verifying accuracy of survey work on request.
- D. Submit certificate signed by ~~Surveyor~~ RPLS, that elevations and locations of the Work are in conformance with the Contract.

1.04 PROJECT RECORD DOCUMENTS

- A. Maintain a complete and accurate log of control and survey work as it progresses.
- B. Prepare a certified survey setting forth dimensions, locations, angles, and elevations of construction and site work upon completion of foundation walls and major site improvements.
- C. Submit record documents under provisions of Section 01785 - Project Record Documents.

1.05 EXAMINATION

- A. Verify locations of survey control points prior to starting the Work.
- B. Notify Project Manager immediately if any discrepancies are discovered.

1.06 SURVEY REFERENCE POINTS

- A. The City will establish survey control datum as provided in Document 00700 - General Conditions and as indicated on Drawings. Inform Project Manager ~~in Advance of time 14 days in advance of recovery of~~ horizontal and vertical control points. ~~will be established so verification deemed necessary by Project Manager may be done with minimum inconvenience to the City or Contractor.~~
- B. Locate and protect survey control points prior to starting site work; preserve permanent reference points during construction.
- C. Notify Project Manager a minimum of 48 hours before relocation of reference points is needed due to changes in grades or other reasons.
- D. Promptly report loss or destruction of reference points to Project Manager.
- E. Reimburse the City for cost of reestablishment of permanent reference points disturbed by construction operations.

1.07 SURVEY REQUIREMENTS

- A. Utilize recognized engineering survey practices.
- B. Establish a minimum of two permanent benchmarks on site, referenced to established control points. Record horizontal and vertical location data on Project record documents.
- C. Establish elevations, lines and levels to provide quantities required for measurement and payment and for appropriate controls for the Work. Locate and lay out the following with appropriate instruments:
 - 1. Site improvements including grading, fill and topsoil placement, utilities, and footings and slabs
 - 2. Grid or axis for structures
 - 3. Building foundation, column locations, and ground floor elevations
- D. Periodically verify layouts.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION - Not Used

END OF SECTION

SECTION 01770

CLOSEOUT PROCEDURES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Procedures to establish Date of Substantial Completion.
- B. Closeout procedures for final submittals, O&M data, warranties, spare parts and maintenance materials.
- C. Texas Department of Licensing and Regulation (TDLR) inspection for Texas Accessibility Standards (TAS) compliance.

1.02 SUBSTANTIAL COMPLETION

- A. Comply with Document 00700 - General Conditions regarding Date of Substantial Completion when Contractor considers the Work, or portion thereof designated by Project Manager, to be substantially complete.
- B. Insure the following items have been completed when included in the Work, prior to presenting a list of items to be inspected by Project Manager for issuance of a Certificate of Substantial Completion:
 - 1. cutting, plugging, and abandoning of water, wastewater, and storm sewer lines, as required by Contract documents for each item;
 - 2. construction of, and repairs to, pavement, driveways, sidewalks, and curbs and gutters;
 - 3. sodding and hydromulch seeding, unless waived by Project Manager in writing;
 - 4. general clean up including pavement markings, transfer of services, successful testing and landscape;
 - 5. additional requirements contained in Section 01110 - Summary of Work.
- C. Assist Project Manager with inspection of Contractor's list of items and complete or correct the items, including items added by Project Manager, within specified time period.
- D. Should Project Manager's inspection show failure of Contractor to comply with requirements to obtain Date of Substantial Completion, including those items in

Paragraph 1.02 B. of this section, Contractor shall complete or correct the items, before requesting another inspection by Project Manager.

1.03 CLOSEOUT PROCEDURES

- A. Comply with Document 00700 - General Conditions regarding final completion and final payment when the Work is complete and ready for Project Manager's final inspection.
- B. Provide Project Record Documents in accordance with Section 01785 - Project Record Documents.
- C. Complete or correct items on punch list, with no new items added. Address new items during warranty period.
- D. The City will occupy portions of the Work as specified in other sections.

1.04 FINAL CLEANING

- A. Execute final cleaning prior to final inspection.
- B. For facilities, clean interior and exterior glass and surfaces exposed to view; remove temporary labels, stains and foreign substances, polish transparent and glossy surfaces, vacuum carpeted and soft surfaces.
- C. Clean equipment and fixtures to sanitary condition.
- D. Clean or replace filters of operating equipment.
- E. Clean debris from roofs, gutters, down spouts, and drainage systems.
- F. Clean site; sweep paved areas, and rake clean landscaped surfaces.
- G. Remove waste and surplus materials, rubbish, and temporary construction facilities from site following final test of utilities and completion of the Work.

1.05 ADJUSTING

- A. Adjust operating equipment to ensure smooth and unhindered operation. Refer to Section 01292 - Schedule of Values, for payment.~~Value of this testing and adjusting is five percent of Lump Sum Price in the Schedule of Values for item being tested.~~

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit O&M data as noted in Section 01330 - Submittal Procedures.

- B. ~~Refer to Section 01292 - Schedule of Values, for payment. Five percent of lump sum amount of each piece of equipment as indicated in Schedule of Unit Price Work or Schedule of Values will be paid after the required O&M data submittals are received and approved by Project Manager.~~

1.07 WARRANTIES

- A. Provide ~~one~~ original of each warranty from Subcontractors, Suppliers, and manufacturers.
- B. Provide Table of Contents and assemble warranties in a 3-ring/D binder with durable plastic cover.
- C. Submit warranties prior to final progress payment.
- D. Warranties shall commence in accordance with the requirements in Document 00700 - General Conditions.

1.08 SPARE PARTS AND MAINTENANCE MATERIALS

- A. Provide Products, spare parts, maintenance and extra materials in quantities specified in individual Specification sections.
- B. Deliver to a location within the City limits as directed by Project Manager. Applicable items must be delivered prior to issuance of a final Certificate for Payment.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION - Not Used

END OF SECTION

SECTION 01782

OPERATIONS AND MAINTENANCE DATA

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Submittal requirements for equipment and facility Operations and Maintenance (O&M) Manuals.

1.02 MEASUREMENT AND PAYMENT

- A. ~~Refer to Section 01292 - Schedule of Values, for payment. Measurement for equipment O&M Manuals is on a lump sum basis equal to five percent of the individual equipment value contained in Schedule of Unit Prices or Schedule of Values. The lump sum amount may be included in the first Progress Payment following approval of the O&M Manuals by Project Manager~~

1.03 SUBMITTALS

- A. Conform to requirements of Section 01330 - Submittal Procedures. Submit a list of O&M Manuals and parts manuals for equipment to be incorporated into the Work.
- B. Submit documents with 8-1/2 x 11-inch text pages, bound in 3-ring/D binders with durable plastic covers.
- C. ~~Print "OPERATION AND MAINTENANCE INSTRUCTIONS", Project title, volume number and subject matter on the cover of each binder. Label the spine of the binder with the project title, volume number and subject matter identical to the cover. Print "OPERATION AND MAINTENANCE INSTRUCTIONS", Project name, and subject matter of binder on covers when multiple binders are required~~
- D. Subdivide contents with permanent page dividers, logically organized according to the Table of Contents, with tab ~~titling titles~~ clearly printed under reinforced laminated plastic tabs.
- E. O&M Manual contents: Prepare a Table of Contents for each volume, with each Product or system description identified.
 - 1. Part 1 - Directory: Listing of names, addresses, and telephone numbers of Design Consultant, Contractor, Subcontractors, and major equipment Suppliers.
 - 2. Part 2 - O&M instructions arranged by system. For each category, identify names, addresses, and telephone numbers of Subcontractors and Suppliers and include the following:

- a. Significant design criteria.
 - b. List of equipment.
 - c. Parts list for each component.
 - d. Operating instructions.
 - e. Maintenance instructions for equipment and systems.
 - f. Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.
 3. Part 3 - Project documents and certificates including:
 - a. Shop Drawings and relevant data.
 - b. Air and water balance reports.
 - c. Certificates.
 - d. Photocopies of warranties.
- F. Submit two copies of O&M Manuals and parts manuals, for review, ~~within no less than~~ one month prior to placing the equipment or facility in service.
- G. Submit one copy of completed volumes in final form 10 days prior to Substantial Completion or partial Substantial Completion inspection~~final inspection~~. One copy with Project Manager comments will be returned after final inspection. Revise content of documents based on Project Manager's comments prior to final submittal.
- H. Submit final volumes to the Project Manager within ten (10) days after Substantial Completion or partial Substantial Completion inspection. Provide three (3) hard copies and one electronic file in PDF format.~~Revise and resubmit three final volumes within 10 days after final inspection.~~

1.04 EQUIPMENT O&M DATA

- A. Furnish O&M Manuals, prepared by manufacturers for all equipment. Manuals must contain, as a minimum, the following:
1. Equipment functions, normal operating characteristics, and limiting conditions.
 2. Assembly, Installation, alignment, adjustment, and checking instructions.
 3. Operating instructions for start-up, normal operation, regulation and control, normal shutdown, and emergency shutdown.
 4. Detailed drawings showing the location of each maintainable part and lubrication point with detailed instructions on disassembly and reassembly of the equipment.
 5. Troubleshooting guide.
 6. Spare parts list, predicted life of parts subject to wear, lists of spare parts recommended to be on hand for both initial start-up and for normal operating

inventory, and local or nearest source of spare parts availability.

7. Outline, cross-section, and assembly drawings with engineering data and wiring diagrams.
 8. Test data and performance curves.
- B. Furnish parts manuals for all equipment, prepared by the equipment manufacturer, which contain, as a minimum, the following:
1. Detailed drawings giving the location of each maintainable part.
 2. Spare parts list with predicted life of parts subject to wear, lists of spare parts recommended on hand for both initial start-up and for normal operating inventory, and local or nearest source of spare parts availability.

PART 2 PRODUCTS - Not Used

PART 3 EXECUTION - Not Used

END OF SECTION

Section 02441

MICROTUNNELING AND PIPE JACKED TUNNELS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Tunnel construction of sewers/pipes by microtunneling one-pass methods with or without man entry. Construction methods involves jacking pipe following hand shield excavation or tunnel boring machine (TBM) or a micro-tunnel boring machine (MTBM), with jacking pipe serving as both tunnel liner during construction and sewer pipe after completion of construction.

A. Tunnel construction of casing pipes for water lines by Microtunneling methods.

Select fiberglass reinforced pipe (FRP), vitrified clay pipe (VCP), reinforced concrete pipe (RCP) for storm or sanitary sewers and reinforced concrete box (RCB) for storm sewers. Use plastic lined RCP for sanitary sewers. Unlined RCP or RCP lined with liner other than that specified in Section 02427 – Plastic Liner for Large-Diameter Concrete Sewers and Structures will not be allowed for sanitary sewers.

1.02 RELATED SECTIONS

A. Section 01330 – Submittal Procedures

B. Section 01576 – Waste Material Disposal

C. Section 01578 - Control of Ground and Surface Water

D. Section 02400 – Tunnel Shafts

E. Section 02401 – Common Tunnel Shafts

B.F. Section 02426 – Sewer Line in Tunnels

G. Section 02427 – Plastic Liner for Large-Diameter Concrete Sewers and Structures

H. Section 02431 – Tunnel Grout

I. Section 02504 – Fiberglass Reinforced Pipe

J. Section 02508 – Extra Strength Clay Pipe

K. Section 02517 – Water Line in Tunnels

L. Section 02533 – Acceptance Testing for Sanitary Sewers

C.M. Section 02611 – Reinforced Concrete Pipe1.021.03 MEASUREMENT AND PAYMENT

A. Unit Prices:-

1. Length of sewer installed will be measured by linear foot along center line of completed sewer from center line to center line of manholes, as designated on Drawings; and to end of stubs or termination of pipe; and to inside face of lift station and treatment plant works. Installation of sewer within limits of structure other than manholes will not be considered for measurement and payment at unit price bid.
2. Payment will include and be full compensation for labor, equipment, materials, and supervision for construction of sewer and excavation, complete in place including disposal of excess materials, sheeting, shoring or bracing, dewatering, utility adjustments, connections to existing sewers, grouting when required, tests, backfilling, clean-up, and other related work necessary for construction as specified or as shown on Drawings.
3. Payment for installation of sewer will be authorized by Project Manager in two parts. Pay estimates for partial payments will be made as measured above according to following schedule:
 - a. 95 percent payment will be made for jacked pipe on linear foot basis for amount of jacked pipe installed but not yet grouted, in cases where grouting is specified.
 - b. 100 percent payment will be authorized on a linear foot basis for amount of jacked ~~sewer~~ pipe installed, including grouting when specified.

4. No separate payment will be made for water lines in casing under this Section. Refer to Section 02517 – Water Line in Tunnels for measurement and payment.

~~Monitoring will be paid for at lump sum price for installations, observations, and reporting.~~

- B. Stipulated Price (Lump Sum): If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.031.04 REFERENCE STANDARDS

- A. American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering-
- B. American Association of State Highway and Transportation Officials (AASHTO)-
- C. ASTM A 36 – Standard Specification for Carbon Structural Steel

- D. ASTM A 139 – Standard Specification for Electric-Fusion (Arc)-Welded Steel Pipe (NPS 4 and Over)
- E. ASTM A 515 – Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate and Higher Temperature Service
- F. ASTM A 572 – Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
- G. ASTM A 1097 – Standard Specification for Steel Casing Pipe, Electric-Fusion (Arc)-Welded (Outside Diameter of 10 in. and Larger)
- C.H. AWWA C200 – Steel Water Pipe-6 in. and Larger
- D.I. National Electrical Code - (NFPA 70)-
- E.J. NSF/ANSI 60 – Drinking Water Chemicals – Health Effects
- F.K. Occupational Safety and Health Administration (OSHA)

1.041.05 DEFINITIONS

- ~~—— Jacked Pipe: Method for installing sewer pipe that serves as initial construction lining and tunnel support, installed for stability and safety during construction, and as sewer pipe. Pipe is shoved forward, or jacked, as tunnel is advanced.~~
- A. Conditioners: Bentonite, foam, polymers and/or other materials added to the excavated materials (cuttings) to modify them. Conditioners are required to form earth paste and an appropriate support medium in the excavation chamber, and to reduce the abrasive nature of the excavated materials.
- B. Critical Structure: Building, structure, bridge, pier, or similar construction partially or entirely located within Zone of Active Excavation, unless otherwise defined in Contract Documents.
- C. Earth Pressure Balance (EPB) MTBM System: A Microtunneling system that incorporates a screw conveyor to facilitate forming of ground controlling plug and removal of excavated soil into muck car. Face and ground water pressure is balanced by pressure of excavated material held back by the plug. Earth pressure balance systems may utilize ground Conditioners to assist in maintaining pressure balance and enhance controllability and operation of system.
- D. Intermediate Jacking Station: Supplementary jacking system installed between two Jacking Pipe sections without use of an additional shaft.
- E. Jacking Pipe: Pipe or casing installed by Microtunneling process that is capable of carrying installation jacking loads in addition to normal pipe loads.

- ~~A.F.~~ Microtunneling: Method of installing ~~pipe~~ by jacking pipe or casing behind ~~M~~microtunnel ~~B~~boring ~~M~~machine ~~which-that~~ is connected to and ~~shoved-jacked~~ forward by pipe or casing being installed, generally precluding man entry for routine operation.
- ~~B.~~ ~~Tunnel Boring Machine (TBM): Mechanized excavating equipment that is steerable, guided and articulated, connected to and shoved forward by pipe being installed, with man entry.~~
- ~~C.G.~~ Microtunnel Boring Machine (MTBM): Mechanized excavating equipment incorporating Pressurized Head that is remotely--controlled, steerable, laser/gyroscope navigational system guided~~and~~, articulated, with controlled face that fully supports excavation face with fluid and/or earth pressure balance at all times and connected to and shoved forward by pipe or casing being installed, usually precluding man entry for routine operation.
- ~~H.~~ Pressurized Head: Bulkhead within MTBM designed to be watertight.
- ~~I.~~ Slurry Pressure Balance MTBM System: A Microtunneling system that uses a low-pressure fluid to balance ground and water pressure at face of tunnel and to transport excavated spoils to surface.
- ~~D.J.~~ Tunneling Methodology Work Plan: Written description, together with supporting documentation that defines plans and procedures for ~~M~~microtunneling ~~or pipe jacking~~ operations.
- ~~—~~ Zone of Active Excavation: Area located within radial distance centered about surface point immediately above face of excavation and with radius equal to depth from ground surface to bottom of excavation, or as otherwise indicated in Drawings.

~~K.~~

1.051.06 SUBMITTALS

- A. Conform to requirements of Section 01330 - Submittal Procedures.
- B. The fFollowing submittals are required:
1. Tunneling Methodology Work Plan: Submit Brief description of proposed tunnel methodology for record purposes. Description should be sufficient to convey the following:
 - a. ~~Proposed method of tunnel construction and t~~Type of face support.
 - b. Manufacturer and type of tunneling equipment proposed.; ~~type of lighting and ventilation systems.~~
 - ~~b.c.~~ Cutter head details.
 - ~~e.d.~~ Locations of access shafts and work sites.

- d.e. Proposed method of machine launch, exit and retrieval.
- e.f. Capacity of jacking equipment and type of cushioning.
- f.g. Planned use of Intermediate Jacking Stations, if applicable, and closure of Intermediate Jacking Stations upon completion of drive.
- h. System of alignment monitoring and steering control and activation.
- i. Lubrication system.
- j. Slurry system for slurry Microtunneling.
- g.k. Soil conditioning, if necessary, for EPB Microtunneling.
- h.l. Number and duration of shifts planned to be worked each day.
- i.m. Sequence of operations.
- j.n. Method of Spoil transportation from face, surface storage, separation, and disposal location.

Identify critical utility crossings and special precautions proposed.

- o. Contingency plan and emergency procedures, including but not limited to machine maintenance and/or component repair, and Jacking Pipe failure.
 - p. Supplementary alignment surveying.
 - q. Lubrication mixing and injection.
 - r. Source of water used in slurry, lubricant, and grout.
2. Drawings and Calculations:- Submit ~~for record purposes~~, drawings and calculations for tunnel support ~~system~~. Provide adequate drawings and installation details for construction. ~~For pipe jacking and microtunneling, s~~Show pipe and pipe joint detail. Documents must be signed and sealed by Professional Engineer registered in State of Texas. Calculations shall include clear statement of criteria used for design as described in ~~Paragraph Article~~ 1.0607.A, Design Criteria Requirements.
- a. Calculations to demonstrate that the maximum jacking loads will not exceed the maximum allowable jacking forces of the MTBM and the Jacking Pipe selected.
 - b. Calculations to demonstrate pipe selected is designed to support maximum anticipated earth loads and superimposed live loads, both static and dynamic, which may be imposed on pipe and additional stresses imposed on the pipe during jacking operations.

- c. Calculations of estimated operating pressure at the tunnel face.
 - d. Calculations demonstrating that jacking shaft and backstop arrangement can safely accommodate maximum calculated jacking load without excessive or detrimental movement.
- 3. 3.—Personnel: Submit for record purposes, résumés for project manager, field superintendent and Microtunneling machine operators.
 - a. Experience: Minimum of 3 previous successful Microtunneling installations of similar size and scope.
 - k.b. Detailed descriptions of Microtunneling projects.
- 2.4. 3Quality Control: ~~Submit for review brief~~ dDescription of quality control methods including:
 - a. Method and frequency of survey control.
 - b. Example of tunnel daily log.
- 3.5. 4Geotechnical Investigation: When geotechnical investigations are conducted, submit results to Project Manager for record purposes.
- 4.6. 5Monitoring Plans.:
 - a. Instrumentation Monitoring Plan: Submit for review, prior to construction, instrumentation monitoring plan that includes schedule of instrumentation design, layout of instrumentation points, equipment installation details, manufacturer's catalog literature, and monitoring report forms.
 - b. Surface Settlement Monitoring Plan.:- Submit surface settlement monitoring plan for review prior to construction. Plan shall identify on planthe location of settlement monitoring points, reference benchmarks, survey frequency and procedures, and reporting formats.
- 5.7. 6Structures Assessment-: Provide preconstruction and post construction assessment reports for Critical Sstructures, ~~namely those located within zone of active excavation from proposed tunnel centerline~~. Include pre- and post-construction survey and assessment (including photographs or video) of existing damage to structures in vicinitywithin the zone of active excavation of sewer alignment in assessment reports.
- 6.8. 7Readings of all Mmonitoring readings shall be submitted to Project Manager.
- 7.9. 8Daily Reports: Maintain shift log as defined in ~~Paragraph Article~~ 3.04.B, Pipe-jacked Tunneling Data; and make available to Project Manager on request.

1.07 DESIGN CRITERIA SYSTEM DESCRIPTIONC.A. Design Requirements.

1. Assume responsibility for selection of appropriate pipe and pipe joints to carry thrust of any jacking forces or other construction loads in combination with overburden, earth and hydrostatic loads. Design of any pipe or casing indicated on Drawings considers in-place loads only and does not take into account any construction loads. Criteria for longitudinal loading (jacking forces) on pipe and joints shall be determined, based on selected method of construction.
2. ~~Jacked-Jacking P~~pipe shall be designed to withstand thrust from MTBM, ~~TBM or shield and pipe~~ advance without damage or distortion. Configure Propulsion main jacking frame shall be configured so that thrust is uniformly distributed and will not damage or distort pipe or casing.
3. Take into account loads from handling and storing.
4. Criteria to be used at railroad crossings shall be Cooper E-80 locomotive loading distributions in accordance with AREMA specifications for culverts. In design, account for additive loadings due to multiple tracks.
5. Criteria to be used for truck loading shall be ~~HL-93 vehicle loading distributions~~ in accordance with the AASHTO LRFD Bridge Design Specification.
6. Provide pipes and casing of diameter shown on Drawings. Substitution of ~~pipe with~~ larger diameter to suit MTBM ~~or TBM~~ equipment availability for sewer lines will only be permitted if demonstrated to satisfaction of Project Manager that design flows and velocities can be achieved.

PART 2 PRODUCTS

2.01 SEWER-JACKING PIPE

- A. Assume responsibility for selecting appropriate pipes and pipe joints to safely carry loads imposed during construction, including jacking forces. Pipe joints shall be flush with outside pipe face when pipes are assembled. Pipe materials shall be as indicated on Drawings or selected from the following if not indicated on Drawings:
 1. Fiberglass Reinforced pipe, joints, and fittings to be in accordance with Section 02504 - Fiberglass Reinforced Pipe.
 2. Vitrified clay pipe, joints and fittings to be in accordance with Section 02508 - Extra Strength Clay Pipe.
 3. Plastic-lined reinforced concrete pipe with joints and fittings to be in accordance with Section 02611 - Reinforced Concrete Pipe and Section 02427 - Plastic Liner for

Large-Diameter Concrete Sewers and Structures. Plastic liner is not required for storm sewers.

4. Steel casing pipe: Provide new, uncoated steel pipe manufactured in accordance with ASTM A 1097 for sewer line applications and ASTM A 1097 and AWWA C200 for water line applications. Joints may be field-welded butt joints or interlocking joints and shall be watertight.
 - a. For field-welded butt-joint casing, manufacture in accordance with ASTM A 139 Grade E, or ASTM A 572 Grade 50. Provide full circumferential welds at butt joints.
 - b. For steel casing pipe with interlocking joints, provide in accordance with the following:
 - 1) Provide ASTM A 36, ASTM A 515, Grade 60, or ASTM A 572, Grade 42 for pipe, and provide minimum ASTM A 36 for connections.
 - 2) Maintain pipe roundness to within 1 percent of specified diameter.
 - 3) Maintain outside circumference to within 1% of nominal specified circumference, or 3/4 inches, minimum.
 - 4) Maintain wall thickness to within 5% of specified thickness.
 - 5) Provide rolled and welded cylinder method utilizing the double submerged arc welding (DSAW) process in sections not less than 8 feet long, except as needed to achieve the final finished length of pipe.
 - 6) Provide complete penetration butt-welded connectors square to ends of pipe sections.
 - 7) Perform welding in accordance with ANSI/AWS D1.1.
 - 8) Examine connections at time of shipment. Reject sections with defects.
 - 9) Mark all sections with manufacturer's name, job number, customer name, outside diameter, wall thickness, and weight per foot.
 - 10) Ship pipe with protective wax coating over machined surfaces.
 - 11) Provide Permalok or approved equal.
 - c. Design stress in pipe wall shall be 50 percent of minimum yield point of steel or 18,000 psi, whichever is less when subjected to loading conditions.

- d. Design deflection to be used in determining wall thickness shall not exceed 3 percent of nominal casing pipe size.
- e. Bedding constant to be used in determining wall thickness shall be 0.10. Lag factors shall be 1.0 for all live loads.
- f. Casing pipe design shall also include stresses due to jacking forces.

- B. Use pipe that is round with smooth, even outer surface, and has joints that allow for easy connections between pipes. Design pipe ends so ~~that~~ jacking loads are evenly distributed around entire pipe joint and ~~such that~~ point loads will not occur when pipe is installed. Pipe used for pipe jacking shall be capable of withstanding all forces ~~that will be~~ imposed by process of installation, as well as final in-place loading conditions. Protect driving ends of pipe and joints against damage.

~~————— Precast Reinforced Box with joints and fittings in accordance with Section 02612 — Precast Reinforced Concrete Box Sewers. Precast concrete box is not acceptable for Sanitary Sewers.~~

- C. A list of approved jacking pipes is included in the City of Houston Wastewater Pre-Approved Products List (Reference COHWW02441-). This list is not applicable for casing pipe.

2.02 GROUT

- A. Grout shall be in accordance with requirements defined in Section 02431 – Tunnel Grout.

2.03 ANNULAR SPACE LUBRICATION

- A. Lubricants shall be NSF 60 approved.
- C.B. Water used for pipe lubrication shall be clean, fresh, and free from oil, organic matter, or other deleterious matter and of neutral pH.

2.04 CONDITIONERS

- A. Conditioners shall be inert or biodegradable, accompanied by the manufacturers' certificate of compliance with Safety Data Sheets (SDS).
- B. Water is no acceptable as a soil conditioner.

2.05 WATER

- D.A. Water used in slurry, lubricant, and grout shall be obtained from potable water source. Soda ash or accepted equal, with submittal of a Safety Data Sheet (SDS), shall be used to adjust pH of water as required in mix design.

PART 3 EXECUTION

3.01 CONSTRUCTION OPERATIONS CRITERIA

- A. Use methods for ~~M~~microtunneling ~~and pipe-jacked tunneling~~ operations that will minimize ground settlement. Select a method ~~which that will~~ controls flow of water ~~and~~ prevents loss of soil into the tunnel and provides stability of the face under anticipated conditions.
- B. Conduct tunneling operations in accordance with applicable safety rules and regulations, OSHA standards and Contractor's safety plan. Use methods ~~which that~~ include due regard for safety of workmen, adjacent structures, utilities, and public and safe means of ingress and egress.
- C. Maintain clean working conditions wherever there is man access.
- ~~D.~~ For tunneling under railroad embankments, highways, or streets, Pperform installation so as to avoid interference with operation of railroads, highways, or streets, except as approved by owner of facility.
- ~~D.E.~~ Shafts required for microtunnel construction shall be in conformance with Section 02400 – Tunnel Shafts and Section 02401 – Common Tunnel Shafts.

~~3.01 GROUND WATER CONTROL~~

- ~~A. Provide ground water control measures in conformance with Section 01578 – Control of Ground and Surface Water, when necessary to perform Work.~~

3.02 EQUIPMENT

- A. Full directional guidance of ~~shield, TBM, or~~ MTBM is prerequisite of this method of construction.
- B. Assume responsibility for selection of tunneling equipment which, based on past experience, has proven to be satisfactory for excavation of soils to be encountered.
- C. Employ tunneling equipment that ~~will be~~ is capable of handling various anticipated ground conditions, ~~and~~ is capable of minimizing loss of soil ahead of and around machine and ~~shall~~ provides satisfactory support of excavated face.
- ~~B. Tunnel Boring Machine (TBM). A TBM used for pipe jacking shall conform to shape of tunnel with uniform perimeter that is free of projections that could produce over excavation or voids. Appropriately sized overcutting bead may be provided to facilitate steering. In addition it shall:~~
 - ~~1. Be capable of full face closure.~~
 - ~~2. Be equipped with appropriate seals to prevent loss of bentonite lubricant.~~

3. ~~Be capable of correcting roll by reverse drive or fins.~~

4. ~~Be designed to handle adverse ground conditions including ground water ingress.~~

~~Be equipped with visual display to show operator actual position of TBM relative to design reference.~~

5.

C. ~~Tunnel Shield. If hand shield is used for pipe jacked tunneling (with or without attached mechanized excavating equipment), shield must be capable of handling various anticipated ground conditions. In addition, shield shall:~~

1. ~~Conform to shape of tunnel with uniform perimeter that is free of projections that could produce over excavation or voids. Appropriately sized overcutting bead may be provided to facilitate steering.~~

2. ~~Be designed to allow face of tunnel to be closed by use of gates or breasting boards without loss of ground.~~

D. Microtunneling Equipment.: ~~In case of MTBM, use spoil transportation system which:~~

1. Slurry Pressure Balance MTBM ~~Balances soil and ground water pressures by use of slurry or earth pressure balance system; s~~System shall be capable of adjustments required to maintain face stability for particular soil condition and shall monitor and continuously balance soil and ground water pressure to prevent loss of slurry or uncontrolled soil and ground water inflow, or, in case of slurry spoil transportation system:

a. Provides pressure at excavation face by use of slurry pumps, pressure control ~~valves~~system, and flow meter.

b. Includes slurry bypass unit in system to allow direction of flow to be changed and isolated, as necessary.

c. ~~Includes separation process. Design it to provide adequate separation of spoil from slurry so that slurry with sediment content within limits required for successful tunneling can be returned to cutting face for reuse. Appropriately contain spoil at site prior to disposal.~~

d. ~~Uses type of separation process suited to size of tunnel being constructed, soil type being excavated, and work space available at each work area for operating plant.~~

e. ~~Allows composition of slurry to be monitored to maintain slurry weight and viscosity limits required.~~

2. ~~In case of cased auger e~~Earth ~~P~~pressure ~~B~~balance MTBM S~~system, system~~ shall be

capable of adjustments required to maintain face stability for particular soil condition to be encountered. Monitor and continuously balance soil and ground water pressure to prevent loss of soil or uncontrolled ground water inflow.

- a. ~~In-cased auger-~~ The spoil transportation system shall be capable of managing, ~~manage~~ pressure at the excavation face by controlling volume of spoil removal with respect to advance rate. Monitor speed of rotation of ~~auger-~~ flight ~~screw conveyor,~~ and addition of water.
3. Remote Control System:- Provide MTBM ~~which-that~~ includes remote control system with following features:
 - a. Allows for operation of system without need for personnel to enter tunnel for routine operations. Has display available to operator, at remote operation console, showing position of shield in relation to design reference together with other information such as face pressure, roll, pitch, steering attitude, valve positions, thrust force, and cutter head torque; rate of advance and installed length.
 - b. Integrates system of excavation and removal of spoil and its simultaneous replacement by pipe. As each pipe section is jacked forward, remote control system shall synchronize all of operational functions of system.
 4. Active Direction Control System:- Provide MTBM ~~which-that~~ includes active direction control system with the following features:
 - a. Controls line and grade by a guidance system that remotely relates actual position of MTBM to design reference ~~(e.g., by laser beam transmitted from jacking shaft along pipe to target mounted in shield)~~.
 - b. Provides active steering information ~~which shall be~~ that is monitored and transmitted to operating console.
 - c. Provides positioning and operation information to operator on control console.
 - ~~5. Use generator which is suitably insulated for noise ("hospital" type) in residential or commercial areas.~~
- E. Pipe Jacking Equipment:- Provide pipe jacking system with the following features:
1. Has main jacks mounted in jacking frame located in starting shaft.
 2. Has jacking frame which successively pushes string of connected pipes following tunneling excavation equipment towards receiving shaft.
 3. Has sufficient jacking capacity to push tunneling excavation equipment and string of pipe through ground. Incorporates Intermediate Jacking Stations, if required.

4. Has capacity at least 20 percent greater than calculated maximum jacking load.
5. Develops uniform distribution of jacking forces on end of pipe by use of spreader rings and packing, ~~measured by operating gauges.~~
6. Provides and maintains pipe lubrication system at all times to lower friction developed on surface of pipe during jacking.
7. Jack Thrust Reactions. Use reactions/thrust walls for pipe jacking that are adequate to support jacking pressure developed by main jacking system. Special care shall be taken when setting pipe guide rails in jacking shaft to ensure correctness of alignment, grade, and stability.

F. Slurry Separation Equipment:- If slurry MTBM is being used, provide a slurry separation system meeting the following requirements:

1. Provide adequate separation of the spoil from the slurry so that slurry content within the limits set by the Contractor's Work Plan can be returned to the cutting face for reuse.
2. Use a mechanical separation plant, including scalping screens, shaker screens, de-sanding and de-silting cones, and centrifuge as deemed necessary by the Work Plan.
3. Appropriately contain spoil at the site before disposal.
4. The type of separation process is suited to the size of the tunnel being constructed, the ground type being excavated, the volume of expected flow generated by the slurry circuit, and the workspace available at each jacking shaft location for operating the plant.
5. Monitor the composition of the slurry to maintain the slurry weight, gel strength, and viscosity limits defined by the Contractor's Work Plan.

F.G. Air Quality:- Provide equipment to maintain proper air quality ~~of assuming~~ manned tunnel operations during construction in accordance with OSHA requirements.

G.H. Where used, Enclose lighting fixtures in watertight enclosures with suitable guards. Provide separate circuits for lighting, and other equipment.

H.I. Electrical systems shall conform to requirements of National Electrical Code - NFPA70.

3.03 PIPE JACKED TUNNELING DATA

A. Utilize a real-time data collection system and make available to the Project Manager on request.

H.B. Maintain shift logs of construction events and observations. Project Manager shall have access to all logs ~~with regard to~~ containing the following required information:

1. Location of boring machine face ~~or shield~~ by station and progress of tunnel drive during shift.
2. Hours worked per shift on tunneling operations.
3. Completed field forms, such as steering control logs, for checking line and grade of tunneling operation, showing achieved tolerance relative to design alignment.
4. Maximum pipe jacking pressures per drive.
5. ~~Location, elevation and brief soil descriptions of soil strata~~Lubricant pressures and estimated quantities, viscosity, and pumping pressure.
- ~~6. Ground water control operations and piezometric levels.~~
- ~~7.6.~~ Observation of any lost ground or other ground movement.
- ~~8.7.~~ Any unusual conditions or events.
- ~~9.8.~~ Reasons for operational shutdown in event drive are halted.

3.033.04 EXCAVATION AND JACKING OF PIPE

A. Tunnel Excavation.:

1. Keep tunnel excavation within easements and rights-of-way indicated on Drawings and to lines and grades designated on Drawings.
2. Perform tunneling operations in a manner that will minimize movement of ground in front of and surrounding tunnel. Prevent damage to structures and utilities above and in vicinity of tunneling operations.
- ~~3. Open face excavations:~~
 - ~~a. Keep face breasted or otherwise supported and prevent falls, excessive raveling, or erosion. Maintain standby face supports for immediate use when needed.~~
 - ~~b.~~
 - ~~c. During shut down periods, support face of excavation by positive means; no support shall rely solely on hydraulic pressure.~~
- ~~4.3. Closed face with P~~pressurized H~~head E~~excavation:
 - a. Carefully control volume of spoil removed. Advance rate and excavation rate to be compatible to avoid over excavation, ~~or~~ loss of ground or ground heave.
 - b. When cutting head is withdrawn or is open for any purpose, keep excavated

face supported and stabilized.

~~5.4. Excavated diameter should be minimum size to permit pipe installation by jacking with allowance for bentonite injection into annular space.~~ Whenever ~~there is a~~ condition is encountered which could endanger tunnel excavation or adjacent structures, operate without intermission including 24-hour working, weekends and holidays, until condition no longer exists. Such conditions shall be brought to the attention of Project Manager within 24 hours.

~~6.5.~~ Assume responsibility for damage due to settlement from any construction-induced activities.

B. Pipe Jacking.

1. Cushion pipe joints as necessary to transmit jacking forces without damage to pipe or pipe joints, in accordance with pipe manufacturer's recommendations.

2. Maintain envelope of bentonite slurry around exterior of pipe during jacking and excavation operation to reduce exterior friction and possibility of pipe seizing in place.

~~2.3.~~ If ~~pipe seizes up in place and elect to construct a~~ recovery access shaft is needed, obtain approval from Project Manager prior to excavation. Coordinate traffic control measures and utility adjustments as necessary prior to commencing work.

~~3.4.~~ In event If a section of pipe is damaged during jacking operation, or joint failure occurs, as evidenced by inspection, visible ground water inflow or other observations, submit for approval Contractor's proposed his methods for repair or replacement of pipe. Document repairs by providing repair locations (station numbers), pictures/videos showing condition of the pipe or joint before and after repairs are done, and a certification from manufacturer's representative that repairs have been inspected and are considered acceptable.

C. Grouting:- Grouting requirements are defined in Section 02431 - Tunnel Grout.

3.043.05 CONTROL OF LINE AND GRADE

A. Construction Control:-

1. Project Manager will establish baselines and benchmarks indicated on Drawings. Check baselines and benchmarks at beginning of Work and report any errors or discrepancies to Project Manager.
2. Use baselines and benchmarks established by Project Manager to establish and maintain construction control points, reference lines and grades for locating tunnel, sewer pipe, and structures.
3. Establish construction control points sufficiently far from work so as not to be

affected by ground movement caused by pipe-jacked tunneling operations.

B. Bench-Mmark Movement:- ~~Ensure that if~~ settlement of ground surface occurs during construction which affects accuracy of temporary benchmarks, detect and report such movement and reestablish temporary bench-marks. Locations of permanent City of Houston monumentation benchmarks are indicated on Drawings. Advise Project Manager of any settlement affecting permanent monumentation benchmarks.

C. Guidance System and Alignment Control.

1. Provide the Project Manager access to the guidance system readings at all times to be able to verify alignment and grade.
2. Initial alignment of equipment and final pipe/casing alignment shall be documented.

B.D. Line and Grade.-

1. Check and record ~~survey control alignment~~ for tunnel against above-ground undisturbed reference ~~at least once for each 250 feet of tunnel constructed after installation of each Jjacking Ppipe.~~
2. Record exact position of MTBM ~~or TBM or shield~~ after each shove to ensure alignment is within specified tolerances. Make immediate correction to alignment before allowable tolerances are exceeded.
3. When excavation is off line or grade, make alignment corrections to avoid reverse grades in gravity sewers.
4. Acceptance criteria for ~~sewer jacking~~ pipe shall be plus or minus 6 ~~inches percent of the MTBM diameter~~ in horizontal alignment or 2 inches, whichever is greater, and plus or minus 3 percent of the MTBM diameter in elevation or 1 inch, whichever is greater, from the design line and grade, unless otherwise indicated on the Drawings. ~~from theoretical at any point between manholes, including receiving end, and plus or minus 1 1/2 inches in elevation from theoretical.~~
5. If it is determined that the pipe cannot be used, Ppipe installed outside tolerances shall be fully grouted and ~~subsequently abandoned shall first be fully grouted.~~

3.053.06 MONITORING

A. Instrumentation Monitoring:- Instrumentation requirements are shown on Drawings. Instrumentation specified shall be accessible at all times to Project Manager. ~~Readings shall be submitted promptly to Project Manager.~~

1. Install and maintain instrumentation system to monitor and detect movement of ground surface and adjacent structures. Establish vertical control points at a distance from construction areas that avoids disturbance due to ground settlement.

2. Installation of instrumentation shall not preclude Project Manager, through independent contractor or consultant, from installing instrumentation in, on, near, or adjacent to construction work. Access shall be provided to work for such independent installations.
3. Instruments shall be installed in accordance with Drawings and manufacturer's recommendations.

B. Surface Settlement Monitoring.

1. Establish monitoring points on all Critical Structures.
2. Record location of settlement monitoring points with respect to construction baselines and elevations. Record elevations to accuracy of 0.01 feet for each monitoring point location. Monitoring points should be established at locations and by methods that protect them from damage by construction operations, tampering, or other external influences.
3. Ground surface elevations shall be recorded on centerline ahead of tunneling operations at minimum of 100-foot intervals or at least three locations per tunnel drive. For sewers greater than 60-inch diameter, also record similar data at approximately 20 feet each side of centerline. Settlement monitoring points must be clearly marked by studs or paint for ease of locating.
4. Railroads. Monitor ground settlement of track subbase at centerline of each track. Follow American Railway Engineering and Maintenance-of-Way Association (AREMA) crossing requirements.
5. Utilities and Pipelines. Monitor ground settlement directly above and at least 10 feet or two excavation diameter, whichever is greater, before and after utility or pipeline intersection as shown on the Drawings.

C. Reading Frequency and Reporting:- Submit to Project Manager, records of readings from various instruments and survey points.

~~1. Instrumentation monitoring results to be read at frequency specified and unless otherwise specified, shall be started prior to zone of active excavation reaching that point, and shall be continued until zone of active excavation has passed and until no further detectable movement occurs.~~

~~2.1. Surface settlement monitoring R~~eadings shall be taken:

- a. Prior to Zone of Aactive Exexcavation reaching that point.
- b. When tunnel face reaches monitoring point (in plan).
- c. When Zone of Aactive Exexcavation has passed and no further movement is detected.

~~3.2.~~ All monitoring readings shall be submitted ~~promptly~~ daily to Project Manager.

~~4.3.~~ Immediately report to Project Manager any movement, cracking, or settlement ~~which~~
~~is~~ detected.

~~5.4.~~ Following substantial completion but prior to final completion, make final survey of
~~all~~ remaining monitoring points and submit to Project Manager.

~~3.06~~3.07 DISPOSAL OF EXCESS MATERIAL

- A. Remove spoil in accordance with Section 01576 - Waste Material Disposal.

~~3.07~~3.08 ACCEPTANCE TESTING FOR SEWERS

- A. Acceptance testing is to be carried out by methods described in Section 02533 - Acceptance Testing for Sanitary Sewer.

END OF SECTION

SECTION 02445

JACK AND BORE/JACK AND MINE/PILOT TUBE GUIDED BORING TUNNELS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Furnishing and installation of pipes by Jack and Bore, Jack and Mine or Pilot Tube Guided Boring.

1.02 RELATED SECTIONS

- A. Section 01330 – Submittal Procedures
- B. Section 01576 – Waste Material Disposal
- C. Section 01578 - Control of Ground and Surface Water
- D. Section 02400 – Tunnel Shafts
- E. Section 02401 – Common Tunnel Shafts
- F. Section 02426 – Sewer Line in Tunnels
- G. Section 02427 – Plastic Liner for Large-Diameter Concrete Sewers and Structures
- H. Section 02431 – Tunnel Grout
- I. Section 02504 – Fiberglass Reinforced Pipe
- J. Section 02508 – Extra Strength Clay Pipe
- K. Section 02517 – Water Line in Tunnels
- L. Section 02533 – Acceptance Testing for Sanitary Sewers
- M. Section 02611 – Reinforced Concrete Pipe
- N. Section 02612 – Precast Reinforced Concrete Box Sewers

1.03 MEASUREMENT AND PAYMENT

- A. Unit Prices.
 - 1. Length of sewer installed will be measured by linear foot along center line of completed sewer from center line to center line of manholes, as designated on Drawings; and to end of stubs or termination of pipe; and to inside face of lift station

and treatment plant works. Installation of sewer within limits of structure other than manholes will not be considered for measurement and payment at unit price bid.

2. Payment will include and be full compensation for labor, equipment, materials, and supervision for construction of sewer or casing and excavation, complete in place including disposal of excess materials, sheeting, shoring or bracing, dewatering, utility adjustments, connections to existing sewers, grouting when required, tests, backfilling, clean-up, and other related work necessary for construction as specified or as shown on Drawings.
 3. Payment for installation of sewer or casing will be authorized by the Project Manager in two parts. Pay estimates for partial payments will be made as measured above according to following schedule:
 - a. 95 percent payment will be made for jacked pipe on linear foot basis for amount of jacked sewer pipe installed but not yet grouted, in cases where grouting is specified.
 - b. Remaining 5 percent payment will be made for jacked pipe on linear foot basis for amount of jacked sewer pipe installed and grouted, in cases where grouting is specified. A 100 percent payment will be made for jacked pipe on linear foot basis for amount of jacked sewer pipe installed, in cases where grouting is not specified.
 4. No separate payment will be paid for water lines in tunnel under this Section. Refer to Section 02511 – Water Lines or Section 02517 – Water Line in Tunnel for measurement and payment.
- B. Stipulated Price (Lump Sum): If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCE STANDARDS

- A. American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering.
- B. American Association of State Highway and Transportation Officials (AASHTO).
- C. ASTM A 36 – Standard Specification for Carbon Structural Steel
- D. ASTM A 139 – Standard Specification for Electric-Fusion (Arc)-Welded Steel Pipe (NPS 4 and Over)
- E. ASTM A 515 – Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate and Higher Temperature Service
- F. ASTM A 572 – Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel

- G. ASTM A 1097 – Standard Specification for Steel Casing Pipe, Electric-Fusion (Arc)-Welded (Outside Diameter of 10 in. and Larger)
- H. AWWA C200 – Steel Water Pipe-6 in. and Larger
- I. National Electrical Code - (NFPA 70).
- J. NSF/ANSI 60 – Drinking Water Chemicals – Health Effects
- K. Occupational Safety and Health Administration (OSHA).

1.05 DEFINITIONS

- A. Critical Structure: Buildings, structures, bridges, piers, or similar construction partially or entirely located within Zone of Active Excavation, or otherwise identified in Drawings.
- B. Jack and Bore: Pipe or casing is installed by jacking process with system that has limited steering capability and does not have continuous face support. Excavation is performed using open face auger.
- C. Jack and Mine: Pipe or casing is installed by jacking it into place from jacking shaft to receiving shaft, using hydraulic jacks while excavation takes place at the face by hand mining or mechanical excavation.
- D. Jacking Pipe: Pipe or casing installed by jacking process and that is capable of carrying installation jacking loads in addition to normal pipe loads.
- E. Pilot Tube Guided Boring: Multi-stage method of installing pipe or casing to line and grade by use of guided pilot tube and followed by enlargement to install pipe or casing.
- F. Work Plan: Written description together with supporting documentation that defines plans and procedures for tunneling operations.
- G. Zone of Active Excavation: Area located within the radial distance centered about surface point immediately above the face of excavation and with radius equal to depth from ground surface to bottom of excavation, or as otherwise indicated in Drawings.

1.06 SUBMITTALS

- A. Conform to requirements of Section 01330 - Submittal Procedures.
- B. The following submittals are required:
 - 1. Work Plan: Written description together with supporting documentation that defines plans and procedures for tunneling operations. Description should be sufficient to convey the following:
 - a. Proposed method of pipe or casing installation and type of face support.
 - b. Installation of jacking or boring supports or back stop. Installation of pipe

- jack or Pilot Tube Guided Boring thrust block.
- c. Jack and Bore system manufacturer's literature describing equipment and proposed jacking system including machine:
 - 1) Dimensions
 - 2) Weight
 - 3) Power and torque capabilities
 - 4) Arrangement and position of jacks and pipe guides
 - 5) Cutterhead configuration details including cutterhead teeth
 - 6) Mucking system
 - 7) Auger size
 - d. Type of lighting and description of ventilation systems when person entry is required.
 - e. Pilot Tube Guided Boring tooling and reaming equipment.
 - f. System of alignment monitoring and steering control and activation.
 - g. Number and duration of shifts planned to be worked each day.
 - h. Sequence of operations.
 - i. Locations of boring and receiving shafts.
 - j. Method of spoil transportation from face, surface storage and disposal location.
 - k. Jacking mechanism including maximum jacking capacity.
 - l. Jacking force monitoring and recording details.
 - m. Capacity of jacking equipment and type of cushioning. Anticipated jacking forces for each drive. Safe jacking capacity of Jacking Pipe.
 - n. Identify critical utility crossings and special precautions proposed.
 - o. Description and details of any temporary underground facility proposed for operation including lights, sump pits, and mud slabs.
 - p. If a thrust block is used, thrust block design calculations and safe capacity.
 - q. Calibration table correlating jacking pressure gage readings and applied load

in tons.

- r. Provisions for injecting slurry for Pilot Tube Guided Boring. Slurry mix design, volume and measurement procedures, pumps, piping, valve arrangements, and pressure gages.
 - s. Provisions for injecting pipe lubricants. Pipe jacking lubricant mix design, including lubricant type, injection volume and measurement procedures, pumps, piping, valve arrangements, and pressure gages.
2. Drawings and Calculations.
- a. Submit drawings and calculations for tunnel support system. Provide adequate drawings and installation details for construction. Shop Drawings shall identify proposed Jack and Bore, Jack and Mine or Pilot Tube Guided Boring method complete in assembled position including locations of equipment, staging, and storage areas, and emergency access around the construction operations. Drawings shall show pipe seals, pipe joint, collars, cushioning materials, and reinforcing details. Calculations shall include clear statement of criteria used for design as described in Article 1.07.A, Design Requirements.
 - b. Drawings for hydraulic jacking system, including hydraulic jack configuration and frame dimensions.
 - c. Provide signed and sealed by a Professional Engineer registered in the State of Texas the following calculations:
 - 1) Confirming maximum allowable loads on pipe will not be exceeded by maximum jacking capacity of the jacking system during Jack and Bore, Jack and Mine, or Pilot Tube Guided Boring operations.
 - 2) Demonstrate pipe selected has been designed to support maximum anticipated earth loads and superimposed live loads, both static and dynamic, which may be imposed on pipe and additional stresses imposed on pipe during jacking operations.
 - 3) Showing maximum expected jacking loads and confirm these are not greater than maximum jacking capacity of jacking system. Calculations should indicate if lubrication is being accounted for.
 - 4) Demonstrating that the jacking shaft and backstop arrangement can safely accommodate the maximum calculated jacking load without excessive or detrimental movement.
3. Personnel – Submit for record purposes, résumés for project manager, field superintendent and tunneling machine operators.
- a. Experience: Minimum of 3 previous successful pipe-jacked tunnel

installations of similar size and scope.

- b. Detailed descriptions of pipe-jacked tunnel projects.
- 4. Quality Control: Description of quality control methods including:
 - a. Method and frequency of survey control.
 - b. Example of daily report.
- 5. Geotechnical Investigation: When geotechnical investigations are conducted, submit results to the Project Manager for record purposes.
- 6. Monitoring Plans:
 - a. Instrumentation Monitoring Plan: Submit for review, prior to construction, monitoring plan that includes schedule of instrumentation design, layout of instrumentation points, equipment installation details, manufacturer's catalog literature, and monitoring report forms.
 - b. Surface Settlement Monitoring Plan. Submit surface settlement monitoring plan for review prior to construction. Plan shall identify the location of settlement monitoring points, reference benchmarks, survey frequency and procedures, and reporting formats.
- 7. Structures Assessment. Provide preconstruction and post construction assessment reports for Critical Structures (including photographs or video).
- 8. Monitoring readings shall be submitted to Project Manager at the frequency indicated in Article 3.07.C.2.
- 9. Daily Reports: Maintain a shift log as defined in Article 3.04 - Tunneling Data and make available to Project Manager on request.

1.07 SYSTEM DESCRIPTION

A. Design Requirements.

- 1. Assume responsibility for selection of appropriate pipe and pipe joints to carry thrust of any jacking forces or other construction loads in combination with overburden, earth and hydrostatic loads. Design of pipe indicated on Drawings considers in-place loads only and does not take into account any construction loads. Criteria for longitudinal loading (jacking forces) on pipe and joints shall be determined, based on selected method of construction.
- 2. Jacking Pipe shall be designed to withstand thrust without damage or distortion. Configure main jacking frame so thrust is uniformly distributed and will not damage or distort pipe.
- 3. Take into account loads from handling and storing.

4. Criteria to be used at railroad crossings shall be Cooper E-80 locomotive loading distributions in accordance with AREMA specifications for culverts. Account for additive loadings due to multiple tracks.
5. Criteria for non-railroad crossings to be in accordance with the AASHTO LRFD Bridge Design Specification.
6. Provide pipes and casing of diameter shown on Drawings. Substitution of pipe with larger diameter to suit equipment availability for sewer lines will only be permitted if demonstrated to satisfaction of the Project Manager that design flows and velocities can be achieved.

PART 2 PRODUCTS

2.01 JACKING PIPE

- A. Pipe joints shall be flush with outside pipe face when pipes are assembled. Pipe materials shall be as indicated on Drawings or selected from the following if not indicated on the Drawings:
 1. Fiberglass Reinforced pipe, joints, and fittings in accordance with Section 02504 - Fiberglass Reinforced Pipe.
 1. Vitrified clay pipe, joints and fittings in accordance with Section 02508 - Extra Strength Clay Pipe.
 2. Plastic-lined reinforced concrete pipe with joints and fittings in accordance with Section 02611 - Reinforced Concrete Pipe and Section 02427 - Plastic Liner for Large-Diameter Concrete Sewers and Structures. Plastic liner is not required for storm sewers.
 3. Steel casing pipe: Provide new, uncoated steel pipe manufactured in accordance with ASTM1097 for sewer line applications and AWWA C200 for water line applications. Joints may be field-welded butt joints or interlocking joints and shall be watertight.
 - a. For field-welded butt-joint casing, manufacture in accordance with ASTM A139 Grade E, or ASTM A572 Grade 50. Provide full circumferential welds at butt joints.
 - b. For steel casing pipe with interlocking joints, provide in accordance with the following:
 - 1) Provide ASTM A36, ASTM A515, Grade 60, or ASTM A572, Grade 42 for pipe, and provide minimum ASTM A36 for connections.
 - 2) Maintain pipe roundness to within 1 percent of specified diameter.
 - 3) Maintain outside circumference to within 1% of nominal specified

circumference, or 3/4 inches, minimum.

- 4) Maintain wall thickness to within 5% of specified thickness.
 - 5) Provide rolled and welded cylinder method utilizing the double submerged arc welding (DSAW) process in sections not less than 8 feet long, except as needed to achieve the final finished length of pipe.
 - 6) Provide complete penetration butt-welded connectors square to ends of pipe sections.
 - 7) Perform welding in accordance with ANSI/AWS D1.1.
 - 8) Examine connections at time of shipment. Reject sections with defects.
 - 9) Mark all sections with manufacturer's name, job number, customer name, outside diameter, wall thickness, and weight per foot.
 - 10) Ship pipe with protective wax coating over machined surfaces.
 - 11) Provide Permalok joints or approved equal.
- c. Design stress in pipe wall shall be 50 percent of minimum yield point of steel or 18,000 psi, whichever is less when subjected to loading conditions.
 - d. Design deflection to be used in determining wall thickness shall not exceed 3 percent of nominal casing pipe size.
 - e. Bedding constant to be used in determining wall thickness shall be 0.10. Lag factors shall be 1.0 for all live loads.
 - f. Casing pipe design shall also include stresses due to jacking forces when pipe is to be installed by jacking method.

- B. Use pipe that is round with smooth, even outer surface, and has joints that allow for easy connections between pipes. Design pipe ends so jacking loads are evenly distributed around entire pipe joint and point loads will not occur when pipe is installed. Jacking Pipe shall be capable of withstanding all forces imposed by process of installation, as well as final in-place loading conditions. Protect driving ends of pipe and joints against damage.
- C. Precast reinforced box with joints and fittings shall be in accordance with Section 02612—Precast Reinforced Concrete Box Sewers. Precast concrete box is not acceptable for sanitary sewers. Precast concrete box is not used for Jack and Bore or Pilot Tube Guided Boring.
- D. For sewer pipe installation, a list of approved jacking pipes is included in the City of Houston Wastewater Pre-Approved Product List (Reference COHWW02441-). This list is not applicable for casing pipe.

2.02 GROUT

- A. Grout shall be in accordance with requirements defined in Section 02431 – Tunnel Grout.

2.03 ANNULAR SPACE LUBRICATION

- A. Lubricants shall be NSF 60 approved.
- B. Water used for pipe lubrication shall be clean, fresh, and free from oil, organic matter, or other deleterious matter and of neutral pH.

2.04 WATER

- A. Water used in slurry, lubricant, and grout shall be obtained from potable water source. Soda ash or accepted equal, with submittal of Safety Data Sheet (SDS), shall be used to adjust pH of water as required in mix design.

PART 3 EXECUTION

3.01 CONSTRUCTION OPERATIONS CRITERIA

- A. Use methods that minimize ground settlement. Select method that controls flow of water and prevents loss of soil into tunnel and provides stability of face under anticipated conditions.
- B. For Jack and Bore, at minimum use a level manometer (dutch level) for guidance. Free boring is not an acceptable method.
- C. For Jack and Mine, use surveying or other means for guidance.
- D. Pilot Tube Guided Boring system shall utilize a two or three phase system as described below:

1. Three Pass System.

- a. Phase 1 – Rigid steel pilot tube in approximately 3-foot lengths shall be installed through ground from boring shaft to receiving shaft by earth displacement with jacking frame. Alignment of pilot tube shall be established with theodolite mounted at rear of boring shaft and set to desired line and grade. Theodolite shall view lighted target in lead or steering pilot tube. Camera shall be fitted to theodolite and transmit image of crosshair and target onto monitor screen to be viewed in boring shaft by operator. As operator advances pilot tube through ground, center of target will drift from crosshair as a result of biased or slanted leading tip of the pilot tube. Operator shall rotate pilot tube as required to orient slanted steering tip toward crosshair and continue to advance pilot tube until it reaches receiving shaft. Check line and grade of bore at the receiving shaft.
- b. Phase 2 – An enlargement casing with an outside diameter up to 1 ½” larger than Jacking Pipe shall be rigidly connected to final pilot tube and advanced into earth behind pilot tube. Auger shall be used inside enlargement casing to

remove material being excavated. Auger shall be contained inside limits of enlargement casing as it progresses along proposed alignment. A train of temporary steel casings with an outside diameter very similar to the enlargement casing shall be used to move enlargement casing from the boring shaft to receiving shaft. Enlargement casing will cut bore hole from boring shaft to receiving shaft and temporary casings will case hole as it is cut. Fit each temporary casing with internal auger to transport excavated material to boring shaft to be removed from shaft and disposed at an approved location. Recover pilot tubes in receiving shaft as temporary casings are installed.

- c. Phase 3 – Jacking Pipe shall be installed directly behind final temporary casing pipe with jacking frame. Casing pipes and augers shall be recovered in receiving shaft as Jacking Pipe is installed.

2. Two Pass System.

- a. Phase 1 – Install pilot tube in same manner described in Phase 1 of Three Pass System.
- b. Phase 2 – Install enlargement casing in same manner described in Phase 2 of Three Phase System. Fit each Jacking Pipe with internal protective-casing pipe to house auger and prevent damage to Jacking Pipe. Install Jacking Pipe directly behind enlargement casing with internal casing rigidly connected to auger chamber of enlargement casing. Manufacture internal casing such that excavated material does not leak excessively into Jacking Pipe. Fit internal casing with protective shoe to protect Jacking Pipe from damage and to support casing and auger at centerline of pipe. Advance Jacking Pipe along proposed alignment with jacking frame thus progressing enlargement casing from boring shaft to receiving shaft with pilot tubes being recovered in receiving shaft. Excavated material shall be funneled into and conveyed through internal casing to boring shaft where it shall be removed from shaft and disposed at approved location. Upon reaching receiving shaft remove enlargement casing and internal casings and augers retracted and recovered at boring shaft.

- E. Conduct operations in accordance with applicable safety rules and regulations, OSHA standards, and Contractor's safety plan. Use methods which include due regard for safety of workmen, adjacent structures, utilities, and public and safe means of ingress and egress.
- F. Maintain clean working conditions wherever there is man access.
- G. Perform installation to avoid interference with operation of railroads, highways, or streets, except as approved by owner of facility.

3.02 GROUND WATER CONTROL

- A. Provide ground water control measures in conformance with Section 01578 - Control of Ground and Surface Water, when necessary to perform Work.

3.03 EQUIPMENT

- A. Assume responsibility for selection of equipment which, based on past experience, has proven to be satisfactory for excavation of soils to be encountered.
- B. Employ equipment that will be capable of handling various anticipated ground conditions and is capable of minimizing loss of soil and shall provide satisfactory support of excavated face.
- C. Tunnel Shield. If hand shield is used for Jack and Mine (with or without attached mechanized excavating equipment), shield must be capable of handling various anticipated ground conditions. In addition, shield shall:
 - 1. Conform to shape of tunnel with uniform perimeter that is free of projections that could produce over-excavation or voids. Appropriately sized overcutting bead may be provided to facilitate steering.
 - 2. Be designed to allow face of tunnel to be closed by use of gates or breasting boards without loss of ground.
- D. The following are minimum requirements for Pilot Tube Guided Boring:
 - 1. Line and Grade Control System: Control system shall include but not be limited to a theodolite, lighted target, camera, and monitor screen. The equipment must be capable of installing the pipe to the desired line and grade.
 - 2. Jacking Frame: The jacking frame shall possess adequate strength to advance the pilot tube, the enlargement casing and the string of Jacking Pipe from the boring shaft to the receiving shaft. The jacking force shall be easily regulated down to the safe working load rating of the Jacking Pipe. The frame shall develop a uniform distribution of jacking forces on the end of the pipe. The auger motor shall possess adequate torque to steer the pilot tube and adequate torque and speed to effectively auger the excavated material from the face of the bore to the boring shaft.
 - 3. Pilot Tube: The pilot tubes shall be constructed of steel in rigid but short sections to accommodate the boring and receiving shafts. The tubes shall rigidly connect to each other, the steering tip and the enlargement casing and have a clear inside diameter large enough to adequately view the lighted target. The tubes shall withstand the torque encountered in the steering process.
 - 4. Enlargement Casing: The enlargement casing shall be constructed of steel to a diameter just larger than the Jacking Pipe and have a leading connection compatible with the pilot tube. The leading face of the enlargement casing shall possess several large openings for the soil to enter as it advances along the proposed alignment. An internal auger chamber shall funnel the excavated material into the temporary full diameter casings of the Three-Phase Process or into the internal auger casings of the Two-Phase Process. Structural members shall connect the leading edge of the casing to the pilot tube connections.

5. Soil Transportation System: The soil transportation system shall consist of an auger train operating inside the full diameter temporary steel casing of the Three-Phase System and an internal casing and auger train operating inside the Jacking Pipe. The internal casings of the Two-Phase Process shall be manufactured to minimize leakage of the excavated material into the Jacking Pipe.
 6. Soil Removal: A soil removal system shall be provided to safely remove the excavated material from the boring shaft to the surface.
 7. Hydraulic Power Unit: The hydraulic power unit shall rest on the surface and be connected to the jacking frame by hoses
 8. Lubrication System: A lubrication system shall be employed to minimize pipe friction to ensure that pipe can be installed from the boring shaft to the receiving shaft within the shaft working load rating of the Jacking Pipe. The system may also be required to minimize the torque required to transport the excavated material to the boring shaft.
- E. Jacking Equipment: Provide jacking system with the following features:
1. Has main jacks mounted in jacking frame located in boring shaft. Jacks shall have individual actuation, synchronized actuation, and maximum thrust control. Jacks shall not exert forces when idle but shall resist displacements.
 2. Control gauges shall be accessible to allow the Project Manager's representative to check readings during excavation.
 3. The maximum thrust on the jacked pipe shall not exceed the safe jacking capacity of the pipe at any point or time.
 4. Has jacking frame which successively pushes a string of connected pipes following tunneling excavation equipment towards the receiving shaft.
 5. Has sufficient jacking capacity to push the tunneling excavation equipment and string of pipe through ground.
 6. Has capacity at least 20 percent greater than calculated maximum jacking load.
 7. Develops uniform distribution of jacking forces on end of pipe by use of spreader rings and packing.
 8. Provides and maintains pipe lubrication system at all times to lower friction developed on surface of pipe during jacking.
 9. Jack Thrust Reactions: Use reaction/thrust walls for pipe jacking that are adequate to support jacking pressure developed by main jacking system. Special care shall be taken when setting pipe guide rails in jacking shaft to ensure correctness of alignment, grade, and stability.

- F. Air Quality: Provide equipment to maintain proper air quality of manned tunnel operations during construction in accordance with OSHA requirements.
- G. Where used, enclose lighting fixtures in watertight enclosures with suitable guards. Provide separate circuits for lighting, and other equipment.
- H. Electrical systems shall conform to requirements of National Electrical Code - NFPA70.

3.04 TUNNELING DATA

- A. Maintain shift logs of construction events and observations. Project Manager shall have continuous access to all logs containing the following required information:
 - 1. Location of bore face by station and progress during shift.
 - 2. Hours worked per shift on tunneling operations.
 - 3. Completed field forms, such as steering control logs, for checking line and grade of tunneling operation, showing achieved tolerance relative to design alignment.
 - 4. Maximum jacking pressures per drive.
 - 5. Lubricant pressures and estimated quantities.
 - 6. Ground water control operations and piezometric levels.
 - 7. Observation of any lost ground or other ground movement.
 - 8. Any unusual conditions or events.
 - 9. Reasons for operational shutdown in the event a drive is halted or stopped.

3.05 EXCAVATION AND JACKING OF PIPE

- A. Excavate material just ahead of Jacking Pipe and remove material through Jacking Pipe as it is forced through ground by jacking, into the space thus provided. In general, excavated material shall be removed as jacking progresses and no accumulation of excavated material within Jacking Pipe will be permitted. Should appreciable loss of ground occur in installations where face of excavation is accessible, voids shall be backpacked promptly to the extent practicable with approved soil cement.
- B. The distance that excavation shall extend beyond end of Jacking Pipe depends on character of material encountered but shall not exceed 2 feet.
- C. Boring for Jack and Bore and Pilot Tube Guided Boring.
 - 1. Boring shall proceed from shaft provided for boring equipment and workers. Boring shall be done mechanically using either a pilot tube or auger method.
 - 2. For auger method, jacking pipe of appropriate diameter equipped with cutter head to

mechanically perform excavation shall be used. Augers shall be of sufficient diameter to convey excavated material to shaft.

3. Remove excavated material from shaft and dispose of properly. Use of water or other fluids in connection with boring operation will be permitted only to the extent needed to lubricate cuttings. Water jetting will not be permitted.

D. Excavation for Jack and Mine.

1. Perform excavation operations in a manner to minimize movement of ground in front of and surrounding tunnel. Prevent damage to structures and utilities above and in vicinity of tunneling operations.
2. Keep face breasted or otherwise supported to prevent falls, excessive raveling, or erosion. Maintain standby face supports for immediate use when needed.
3. During shut-down periods, support face of excavation by positive means; no support shall rely solely on hydraulic pressure.

E. Assume responsibility for damage due to settlement from any construction-induced activities.

F. Jacking Operation.

1. Provide a suitable jacking frame or backstop.
2. Set pipe to be jacked on guides properly braced together, to support section of pipe and to direct proper line and grade. Place complete jacking assembly to line up with direction and grade of pipe.
3. Cushion pipe joints as necessary to transmit jacking forces without damage to pipe or pipe joints, in accordance with pipe manufacturer's recommendations. For plywood cushioning material, use ½-inch minimum thickness for pipe diameter 30 inches or less and use ¾-inch minimum thickness for pipe diameter greater than 30 inches.
4. Maintain envelope of bentonite slurry around exterior of pipe during jacking and excavation operation to reduce exterior friction and possibility of pipe seizing in place.
5. If a recovery access shaft is needed, obtain approval from Project Manager prior to excavation. Coordinate traffic control measures and utility adjustments as necessary prior to commencing work.
6. If a section of pipe is damaged during jacking operation, or joint failure occurs, as evidenced by inspection, visible ground water inflow or other observations, submit for approval methods for repair or replacement of pipe. Proposed repair methods shall follow pipe manufacturer's recommendations.

G. Grouting: Grouting requirements are defined in Section 02431 – Tunnel Grout.

3.06 CONTROL OF LINE AND GRADE

A. Construction Control.

1. Project Manager will establish baselines and benchmarks indicated on Drawings. Check baselines and benchmarks at beginning of Work and report any errors or discrepancies to Project Manager.
2. Use baselines and benchmarks established by Project Manager to establish and maintain construction control points, reference lines and grades for locating tunnel, sewer pipe, and structures.
3. Establish construction control points sufficiently far from work so as not to be affected by ground movement caused by pipe-jacked tunneling operations.

B. Benchmark Movement: If settlement of ground surface occurs during construction which affects accuracy of temporary benchmarks, detect and report such movement and reestablish temporary benchmarks. Locations of permanent City of Houston monumentation benchmarks are indicated on Drawings. Advise Project Manager of any settlement affecting permanent monumentation benchmarks.

C. Guidance System and Alignment Control for Jack and Mine and Jack and Bore.

1. A laser guidance system shall be used to determine location at front of jacked pipe relative to laser.
2. Guidance system shall include target to indicate deviations in line and grade.
3. Equip system with means by which Project Manager can verify casing alignment and grade, such as access to laser guidance system.
4. Initial alignment of equipment and final alignment shall be documented.

D. Line and Grade.

1. Check and record alignment for tunnel against above-ground undisturbed reference after installation of each Jacking Pipe.
2. Record exact face location after each shove to ensure alignment is within specified tolerances. Make immediate correction to alignment before allowable tolerances are exceeded.
3. When excavation is off line or grade, make alignment corrections to avoid reverse grades in gravity sewers.
4. Acceptance criteria for sewer pipe shall be plus or minus 6-inches in horizontal alignment from theoretical at any point between manholes, including receiving end, and plus or minus 1 1/2-inches in elevation from theoretical, unless otherwise indicated on Drawings.

5. If it is determined that pipe cannot be used, pipe installed outside tolerances shall be fully grouted and abandoned.

3.07 MONITORING

- A. Instrumentation Monitoring: Instrumentation requirements are shown on Drawings. Instrumentation specified shall be accessible at all times to Project Manager.
 1. Install and maintain instrumentation system to monitor and detect movement of ground surface and adjacent structures. Establish vertical control points at a distance from construction areas that avoids disturbance due to ground settlement.
 2. Installation of instrumentation shall not preclude Project Manager, through independent contractor or consultant, from installing instrumentation in, on, near, or adjacent to construction work. Access shall be provided to work for such independent installations.
 3. Instruments shall be installed in accordance with Drawings and manufacturer's recommendations.
- B. Surface Settlement Monitoring.
 1. Establish monitoring points on all Critical Structures.
 2. Record location of settlement monitoring points with respect to construction baselines and elevations. Record elevations to accuracy of 0.01 feet for each monitoring point location. Monitoring points should be established at locations and by methods that protect them from damage by construction operations, tampering, or other external influences.
 3. Ground surface elevations shall be recorded on centerline ahead of tunneling operations at minimum of 100-foot intervals or at least three locations per tunnel drive. For Jacking Pipe greater than 60-inch diameter, also record similar data at approximately 20 feet each side of centerline. Settlement monitoring points must be clearly marked by studs or paint for ease of locating.
 4. Railroads: Monitor ground settlement of track subbase at centerline of each track. Follow American Railway Engineering and Maintenance-of-Way Association (AREMA) crossing requirements.
 5. Utilities and Pipelines: Monitor ground settlement directly above and at least 10 feet or two excavation diameters, whichever is greater, before and after utility or pipeline intersection as shown on the Drawings.
- C. Reading Frequency and Reporting: Submit to Project Manager records of readings from various instruments and survey points.
 1. Readings shall be taken:

- a. Prior to Zone of Active Excavation reaching that point.
 - b. When tunnel face reaches monitoring point (in plan).
 - c. When Zone of Active Excavation has passed, and no further movement is detected.
2. All monitoring readings shall be submitted daily to Project Manager.
3. Immediately report to Project Manager any movement, cracking, or settlement which is detected.
4. Following substantial completion but prior to final completion, make final survey of remaining monitoring points and submit to Project Manager.

3.08 DISPOSAL OF EXCESS MATERIAL

- A. Remove spoil in accordance with Section 01576 - Waste Material Disposal.

3.09 ACCEPTANCE TESTING FOR SEWERS

- A. Acceptance testing is to be carried out by methods described in Section 02533 - Acceptance Testing for Sanitary Sewer.

END OF SECTION

SECTION 02447

INSTALLATION OF WATER LINES
BY SLURRY BORE

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Installing water line pipe up to 20-inches in diameter or casing pipe up to 24-inch diameter by methods of slurry bore.
- B. For pilot tube guided boring installation, refer to Section 02445 – Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels.

1.02 RELATED SECTIONS:

- A. Section 01576 – Waste Material Disposal
- B. Section 01578 - Control of Ground & Surface Water
- C. Section 02260 – Trench Safety System
- D. Section 02317 – Excavation and Backfill for Utilities
- E. Section 02400 – Tunnel Shafts
- F. Section 02431 – Tunnel Grout
- G. Section 02502 – Steel Pipe & Fittings
- H. Section 02511 – Water Lines
- I. Section 02517 – Water Line in Tunnels
- J. Section 15640 - Joint Bonding and Electrical Isolation

1.03 MEASUREMENT AND PAYMENT

- A. Unit Prices.
 - 1. No separate payment will be made for pipe installation by slurry bore installation under this Section. Include payment in unit price work for Section 02511 – Water Lines.
 - 2. Refer to Section 01270 – Measurement and Payment for unit price procedures.

- B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 DEFINITIONS

- A. Carrier Pipe: Permanent pipe that is used to convey flows.
- B. Casing: Pipe installed to support ground and provide a stable underground excavation for installation of Carrier Pipe.
- C. Obstruction: Objects located wholly or partially within cross-sectional area excavated that prevent forward movement after all diligent efforts to advance past object have failed.
- D. Slurry Bore Method: Installation of casing or pipe by first drilling smaller pilot hole from pit to pit, followed by removing excess soil by reaming the hole larger and installation pipe or conduit by pull-back or jacking method.
- E. Work Plan: Written description together with supporting documentation that defines plans and procedures for slurry bore operations.

1.05 REFERENCE STANDARDS

- A. ASTM D256 - Standard Test Methods For Determining The Izod Pendulum Impact Resistance Of Plastics.
- B. ASTM D638 - Standard Test Method For Tensile Properties Of Plastics.
- C. ASTM D648 - Standard Test Method For Deflection Temperature Of Plastics Under Flexural Load In The Edgewise Position.
- D. ASTM D695 - Standard Test Method For Compressive Properties Of Rigid Plastics.
- E. ASTM D785 - Standard Test Method For Rockwell Hardness Of Plastics And Electrical Insulating Materials.
- F. ASTM D790 - Standard Test Methods For Flexural Properties Of Unreinforced And Reinforced Plastics And Electrical Insulating Materials.
- G. ISO 9001:2015: Quality Management Systems – Requirements.
- H. NSF/ANSI 61: Drinking Water System Components – Health Effects.
- I. Occupational Safety and Health Administration (OSHA) Part 1926 – Safety and Health Regulations for Construction.

1.06 SUBMITTALS

- A. Conform to requirements of Section 01330 – Submittal Procedures.

- B. Qualification Statements: Submit resumes and other evidence of qualifications and experience for key design and field personnel, including project manager, field superintendent and equipment operators. Minimum 5 years experience in slurry bore methods is required.
- C. Work Plan: Submit the following items, at a minimum, in the Work Plan, including drawings:
 - 1. Bore pit layout including locations, sizes, depths and areas for storage material, and spoil handing.
 - 2. Arrangement drawings and technical specifications of slurry bore machine and boring unit and experience record with this type of machine. Include the following information concerning the slurry bore machine: dimensions, cutters, cutterhead position relative to pipe or casing, pipe or casing and band diameters, torque, speed and thrust, procedure for replacing cutters, overcut, and mucking system.
 - 3. Method of maintaining and controlling line and grade of slurry bore operation.
 - 4. Method and details of spoil removal, including equipment type and numbers, processing, and disposal procedures and locations.
 - 5. Techniques to be used for lubrication including equipment, pumping and injection procedures, pressure grout types, and mixtures, in accordance with manufacturer's recommendations.
 - 6. Details of Slurry Boring Method and operation including Carrier Pipe and Casing, if applicable.
 - 7. Plans for storage and handling of pipe and Casing, if applicable.
 - 8. Slurry mix design, volume and measurement procedures, pumps, piping, valve arrangements, and pressure gauges.
- D. Submit shoring system for bore pits in accordance with Section 02400 – Tunnel Shafts.
- E. For water lines in casing, submit manufacturer's data on casing spacers.
- F. Quality Control Methods: Submit description of quality control methods proposed for slurry bore operation. Include the following:
 - 1. Supervisory control to ensure that Work is performed in accordance with Drawings and Specifications.
 - 2. Line and grade: Procedures for surveying, controlling, and checking line and grade, including field forms.
 - 3. Observation and Monitoring: Procedures for preparing and submitting daily logs of

operations, including field forms.

4. Disposal of surface discharge.
5. Groundwater control and drainage.

G. Contingency Plans: The following list includes problem scenarios that may be encountered during slurry bore operations. Submit contingency plans for dealing with each problem scenario while satisfying Specifications. Include observations and measurements required to identify cause of problems.

1. Machine Unable to Advance:
 - a. Insufficient reamer torque or jacking capacity.
 - b. Machine malfunction.
 - c. Excess cutter wear or damage requiring access to replace or repair cutters.
 - d. Obstruction in path of cutter head.
2. Spoil Feed Problems:
 - a. Strong hydrocarbon smell is detected in spoils or in shaft.
 - b. Obstruction jamming mucking system.
3. Jacking Forces:
 - a. Jacking forces increase dramatically or suddenly.
 - b. Jacking forces reach design capacity of casing, jacking frame, or thrust wall (treat these scenarios as separate incidents).
4. Settlement and Subsidence:
 - a. Plan to manage unraveling soils.
5. Line and grade tolerances being exceeded:
 - a. Level system subject to physical disturbance.
6. Pipe has been damaged or has been found to be out of compliance with Specifications during, or after installation.
7. Thrust block (if applicable) deforms excessively under jacking loads or provides insufficient capacity to advance casing.

1.07 SYSTEM DESCRIPTION

A. Design Requirements.

1. Select slurry bore equipment suitable for and capable of efficiently advancing through the geologic conditions anticipated by the Contractor.
2. For all bores, provide a means to measure grade during installation.
3. Methods and equipment shall control surface settlement and heave above the pipeline to prevent damage to existing utilities, facilities, and improvements. Limit ground movements (settlement/heave) to values that do not cause damage or distress to surface features, utilities, or improvements. Monitor survey control points before, during and after installation.
4. Use thrust block to transfer jacking loads to soil behind jacking shaft. Construct thrust block face perpendicular to proposed casing alignment. Design thrust block to withstand the maximum jacking forces developed by main jacks, without excessive deflection or displacement. Do not exceed allowable passive earth pressure, with a minimum factor of safety of 2.0 of forces applied to soil.

1.08 QUALITY ASSURANCE

- A. Perform slurry bore work by an experienced subcontractor who has at least 5 years of experience in performing slurry bore work in similar soil conditions and has completed at least three similar projects involving at least a 250-foot slurry bore on each project. Provide subcontractor superintendent with at least 5 years of experience supervising slurry bore operations. Provide slurry bore machine operator(s) technically trained in operation of proposed slurry bore equipment and having completed, as primary operator, at least three similar slurry bore projects involving at least 250-foot slurry bore in similar subsurface conditions on each project. Provide a site safety representative and personnel responsible for air quality monitoring experienced in tunnel construction and having current certification by OSHA.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Carrier Pipe: Pipes used as a carrier pipe shall conform Section 02511 – Water Lines.
- B. Steel Casing Pipe: Steel Casing to serve as continuous Casing for Carrier Pipe shall conform to Section 02502 – Steel Pipe and Fittings.
- C. Grout: Refer to Section 02431 – Tunnel Grout.
- D. Casing Spacers and End Seals: Provide carbon steel, polypropylene or polyethylene casing spacers in accordance with the following requirements. Install in accordance with manufacturer's recommendations. Casing Spacer manufacturer to be certified conformance with ISO 9001:2015.

1. Carbon Steel Spacers:
 - a. Carbon steel spacers with thermoplastic coating may be provided for water lines up to 20-inches in diameter.
 - b. Band width and spacing: For water lines up to 12-inches in diameter, provide 8-inch wide band. For water lines larger than 12-inches in diameter, provide 12-inch wide band. Install every 6 to 8 feet along carrier pipe as recommended by manufacturer.
 - c. Band: 14 gauge, hot rolled, pickled & oiled steel.
 - d. Riser: 10 gauge, hot rolled, pickled and oiled steel.
 - e. Liner: PVC with dielectric strength 60,000 V min. Thickness 0.090-inches, and Hardness 80 Durometer.
 - f. Bolts, Nuts and Washers: Electro-plated.
 - g. Runners: Glass-filled polymer plastic with Rockwell Hardness (M) (ASTM D785) – 101, Tensile Strength (ASTM D638) – 27,000 psi, Flexural Strength (ASTM D790) – 38,000 psi, Deflection Temperature at 264 psi – 480 F (ASTM D648).
 - h. Finish: Thermoplastic powder coating 10-16 mil thickness.
2. Polypropylene Spacers:
 - a. Polypropylene spacers may be provided for water lines up to 20-inches in diameter. Install every 8 feet or less according to manufacturer's recommendations.
 - b. Provide non-metallic, UV-resistant, virgin polypropylene, molded in segments for field assembly without any special tools. Secure segments around carrier pipe by insertion of a slide-lock.
 - c. Compressive strength 4,000 psi; Dielectric Strength 365 Volts/mil; Impact Strength 1.8 ft.-lbs/inch.
 - d. Skids to be integrally molded with spacer band and shall extend beyond bell or mechanical joint of the carrier pipe to maintain clearance.
3. Polyethylene Spacers:
 - a. Polyethylene spacers may be provided for ductile iron pipe up to 12-inches in diameter and PVC pipe up to 20-inches in diameter. Install every five feet along carrier pipe as recommended by manufacturer.
 - b. Injection molded polyethylene material to provide Flexural Strength (ASTM

D790) 4,600 psi; Compressive Strength (ASTM D695) 4,600 psi; Tensile Strength (ASTM D638) 4,600 psi; and Impact Strength (ASTM D256) 1.3 ft. lb/in.

- c. Skids to be integrally molded with spacer band and shall extend beyond bell or mechanical joint of the carrier pipe to maintain clearance.
- d. Bolts, Nuts and Washers: Electro-plated.
- 4. Refer to City of Houston's Pre-Approved Products List.
- 5. End Seals: Refer to Section 15640 – Joint Bonding and Electrical Isolation and City of Houston's Pre-Approved Products List.

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

- A. Do not discharge surface water inflows into storm sewers, sanitary sewers, drainage ditches, water bodies, or streets without an approved discharge permit.
- B. Conduct operations such that trucks and other vehicles do not interfere with traffic or create mud, dust, or noise nuisance in streets and to adjacent properties.
- C. Promptly clean up, remove, and dispose of spoils spillage, and any material discharges. Do not discharge slurry or spoils into storm sewers, sanitary sewers, drainage ditches, water bodies or streets. Conform to Section 01576 – Waste Material Disposal.
- D. Conduct Work so as not to disturb roadways, railways, adjacent structures, private properties, landscaped areas, or existing utilities. Repair damage immediately to original or better condition and to the satisfaction of Project Manager.
- E. Overnight staging of equipment and security: Utilize temporary fencing to secure equipment and work zone.

3.02 BORE PITS

- A. Locate bore pits within rights-of-way where there is minimum interference with traffic or access to property.
- B. Size pits to provide adequate room to meet operational requirements for slurry bore construction.
- C. Install sheeting, lining, shoring and bracing required for protection of workmen and public in accordance with Section 02260 – Trench Safety System.
- D. Provide groundwater control and drainage from pits while work is in progress and until pit is properly backfilled. Conform to requirements of Section 01578 – Control of Ground and

Surface Water.

- E. Provide and properly maintain safety protection against traffic, and accidental or unauthorized entry. Make provisions to include concrete traffic barrier or other suitable barrier around periphery of pit as appropriate. Fully cover and secure pits where no construction activity is in progress.
- F. Backfill pits in accordance with Section 02317 – Excavation and Backfill for Utilities.

3.03 JACKING OPERATIONS

- A. Provide suitable jacking frame and thrust block (if required) to carry out Work.
- B. Pipe or Casing used in jacking operations must be designed to withstand jacking forces.
- C. Transport pipe or Casing from storage to bore pit without damage. Utilize transport methods acceptable to Casing manufacturer. Do not use damaged pipe or Casing in Work. Set the Casing on properly braced and supported guide rails or jacking frame.
- D. Distribute axial forces from thrust jacks to pipe or casing uniformly through thrust ring and cushion material, if applicable, to prevent damage to ends of pipe. Do not exceed the specified allowable compressive stresses for jacking forces applied to the pipe or Casing.
- E. Jack Casing into position following design line and grade without damaging pipe or Casing.

3.04 SLURRY BORE METHOD

- A. Complete slurry bore in accordance with approved Submittals, and applicable permit conditions.
- B. Conduct slurry bore operations to control surface settlement and heave above pipe or casing to prevent damage to existing utilities, facilities, and improvements. Repair damage resulting from construction activities. Pressure grout voids caused by or encountered during the shaft construction and slurry bore. Modify equipment and procedures as required to avoid recurrence of excessive settlements or damage.
- C. Control the advance of bore and casing so as to restrict excavation of the materials to volume equal to pipe jacked plus allowance for allowable radial overcut, to prevent loss of ground and settlement or possible damage to overlying structures. Control advance rate and monitor volume of material excavated and adjust advance rate, as required, to avoid loss of ground, over excavation, or surface heave.
- D. Diameter of bore hole to not exceed outer diameter of pipe plus 2 inches.
- E. Completely contain, transport, and dispose of excavated materials and fluid additives away from construction site. Contain spoils in trucks or other containers. Dumping of spoil on ground, discharge into sewers or ditches, or discharge into bore pits is not permitted. Only use disposal sites identified in approved Submittals for muck and spoil disposal.

- F. Lubricants shall be NSF 61 approved. Water used for pipe lubrication shall be clean, fresh, and free from oil, organic matter, or other deleterious matter and of neutral pH.

3.05 CONTROL OF LINE AND GRADE

- A. Establish and protect benchmarks as necessary prior to start of construction.
- B. After establishing required benchmarks, use these benchmarks to furnish and maintain reference lines and grades for slurry bore.
- C. Control bore and pipe or Casing advancement to maintain line and grade within tolerances specified. If the installation is off line or grade, attempt to make necessary corrections. Mount guidance system independently from thrust block and jacking frame to maintain alignment if there is movement of equipment during jacking. Stop boring operations and reset guidance system, if its alignment shifts or is moved off design alignment and grade for any reason. Check guidance system setup at least once per shift. Guidance system should only be reset by experienced, competent surveying personnel in accordance with approved procedures outlined in the Submittals.
- D. Monitor line and grade during slurry bore operations. Record deviation with respect to design line and grade at least once per shift and submit records to Project Manager as requested. Control line and grade of pipe or Casing to within 6-inch tolerance of line and grade shown on Drawings.
- E. Correct installation, including any necessary redesign and acquisition of necessary easements, if pipe or Casing installation does not meet specified tolerance. Performance of corrective work is subject to the written approval of Project Manager.

3.06 GROUTING

- A. Refer to Section 02431 – Tunnel Grout.
- B. After pipe is installed, block void space around approximately the first 12 inches of pipe with packed clay to prevent bedding or backfill from entering void around pipe when pit is backfilled.

3.07 INSTALLATION OF CARRIER PIPE

- A. For Carrier Pipe inside Casing, follow installation guide for casing spacer installation provided by the manufacturer. Refer to Section 02517 -Water Line in Tunnels.

3.08 CLEANUP

- A. Refer to Section 01576 – Waste Material Disposal.

END OF SECTION

SECTION 02501

DUCTILE IRON PIPE AND FITTINGS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Ductile iron pipe and fittings for water lines, wastewater force mains, gravity sanitary sewers, and storm sewers.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

- 1. No separate payment will be made for ductile iron pipe and fittings under this Section, with the exception of extra fittings in place. Include cost in unit prices for work as specified in the following Sections, as applicable:

- a. Section 02511 - Water lines
- b. Section 02531 - Gravity Sanitary Sewers
- c. Section 02532 - Sanitary Sewer Force Mains
- d. Section 02631 - Storm Sewers

- 2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

- B. Extra Ductile Iron Compact Fittings in Place shall be for additional fittings required to complete job. This is not to exclude extension of pipe across driveway or intersection for purpose of terminating line in more advantageous position. This determination shall be at discretion of Project Manager. This bid item includes additional fittings as may be necessary to complete job in conformance with intent of Drawings.

- C. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03 REFERENCES

- A. ANSI A 21.4 (AWWA C 104) - Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
- B. ANSI A 21.10 (AWWA C 110) - Standard for Ductile-Iron and Gray-Iron Fittings, 3-in. through 48-in.

- C. ANSI A 21.11 (AWWA C 111) - Standard for Rubber Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
- D. ANSI A 21.15 (AWWA C 115) - Standard for Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges.
- E. ANSI A 21.16 (AWWA C 116) - Protective Fusion Bonded Epoxy Coating for the Interior and Exterior Surfaces of Ductile Iron and Grey Iron Fittings.
- F. ANSI A 21.50 (AWWA C 150) - Standard for Thickness Design of Ductile-Iron Pipe.
- G. ANSI A 21.51 (AWWA C 151) - Standard for Ductile-Iron Pipe, Centrifugally Cast .
- H. ANSI A 21.53 (AWWA C 153) - Standard for Ductile Iron Compact Fittings, 3 inches through 24 inches and 54 inches through 64 inches for Water Service.
- I. ANSI/AWS D11.2 –Guide for Welding Iron Castings.
- J. ASME B 16.1 - Cast Iron Pipe Flanges and Flanged Fittings.
- K. ASTM D 1248 - Standard Specification Polyethylene Plastics Molding and Extrusion Materials for Wire and Cable.
- L. ASTM F 477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
- M. ASTM G 62 - Standard Test Methods for Holiday Detection in Pipeline Coatings.
- N. AWWA C 104/ANSI A 21.4 - Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
- O. AWWA C 110/ANSI A 21.10 - Standard for Ductile-Iron and Gray-Iron Fittings, 3-in. through 48-in.
- P. AWWA C 111/ANSI A 21.11 - Standard for Rubber Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
- Q. AWWA C 115/ANSI A 21.15 - Standard for Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges.
- R. AWWA C 116/ANSI A21.16 - Protective Fusion Bonded Epoxy Coating for the Interior and Exterior Surfaces of Ductile Iron and Grey iron Fittings.
- S. AWWA C 150/ANSI A 21.50 - Standard for Thickness Design of Ductile-Iron Pipe.
- T. AWWA C 151/ANSI A 21.51 - Standard for Ductile-Iron Pipe, Centrifugally Cast.

- U. AWWA C 153/ANSI A 21.53 - Standard for Ductile Iron Compact Fittings, 3 inches through 24 inches and 54 inches through 64 inches for Water Service.
- V. AWWA C 105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
- W. AWWA C 300 - Standard for Prestressed Concrete Pressure Pipe, Steel-Cylinder Type, for Water and other Liquids.
- X. AWWA C 600 - Standard for Installation of Ductile-Iron Water Mains and Their Appurtenances.
- Y. AWWA M 41 – Ductile-Iron Pipe and Fittings.
- Z. SSPC-SP 6 - Steel Structures Painting Council, Commercial Blast Cleaning.
- AA. American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering.
- BB. American Association of State Highway Transportation Officials (AASHTO).
- CC. DIPRA – Thrust Restraint Design for Ductile Iron Pipe.
- DD. NSF/ANSI 61 – Drinking Water System Components – Health Effects

1.04 SUBMITTALS

- A. Conform to requirements of Section 01330 - Submittal Procedures.
- B. For pipes 16 inches and greater submit shop drawings signed and sealed by Professional Engineer registered in State of Texas showing the following:
 - 1. Manufacturer's pipe design calculations.
 - 2. Provide lay schedule of pictorial nature indicating alignment and grade, laying dimensions, fitting, flange, and special details, with plan view of each pipe segment sketched, detailing pipe invert elevations, horizontal bends, restrained joints, and other critical features. Indicate station numbers for pipe and fittings corresponding to Drawings. Do not start production of pipe and fittings prior to review and approval by Project Manager. Provide final approved lay schedule on CD-ROM in Adobe portable document format (*.PDF).
 - 3. Calculations and limits of thrust restraint shall be based on AWWA M41 or DIPRA Thrust Restraint for Ductile Iron Pipe, latest edition.
 - 4. Class and length of joint.
- C. Submit manufacturer's certifications that ductile iron pipe and fittings meet provisions of this

Section and have been hydrostatically tested at factory and meet requirements of ANSI A 21.51.

- D. Submit certifications that pipe joints have been tested and meet requirements of ANSI A 21.11.
- E. Submit affidavit of compliance in accordance with ANSI A21.16 for fittings with fusion bonded epoxy coatings or linings.

PART 2 PRODUCTS

2.01 DUCTILE IRON PIPE

- A. Ductile Iron Pipe Barrels: Shall conform to AWWA C115, C150 and C151 and bear mark of Underwriters' Laboratories approval. Provide minimum thickness Class 52 for sanitary sewers. Unless otherwise shown on Drawings, use a minimum Pressure Class 250 for water lines less than or equal to 20-inch diameter. For 24-inch and larger, design for project specific hydraulics as per AWWA C150. Use minimum Pressure Class 350 for water lines in casing or trenchless construction and for flanged pipe.
- B. Provide pipe sections in standard lengths, not less than 18 feet long, except for special fittings and closure sections as indicated on shop drawings.
- C. For 24-inch and larger water lines, furnish and install cathodic protection in accordance with Section 16640 - Cathodic Protection for Pipelines
- D. For sanitary sewer lines, modify pipe for cathodic protection in accordance with Section 16640 - Cathodic Protection for Pipelines. In lieu of furnishing ductile iron pipe with cathodic protection system, furnish ductile iron pipe with polyethylene encasement, provided the following criteria is met:
 - 1. Provide minimum thickness class.
 - 2. Provide polyethylene encasement material and installation in accordance with AWWA C105, and backfill as specified. Minimum of two complete wraps of 8-mil-thick polyethylene.
 - 3. Use polyethylene encasement for open cut installations only. For augered sections or sections installed inside a casing, provide coating in accordance with paragraph 2.05 D.1.
 - 4. Adhere to other requirements specified herein (e.g., insulation kits, etc.).
- E. For use of pressure class pipe for water lines, design pipe and fittings to withstand most critical simultaneous application of external loads and internal pressures. Base design on minimum of AASHTO HL-93 loading, AREMA E-80 loads and depths of bury as indicated

on Drawings. Design pipes with Marston's earth loads for a transition width trench for zero to 16 feet of cover. Use Marston's earth loads for a trench width of O.D. (of pipe) + 4 feet for pipe greater than 16 feet of cover. Use Marston's equations for a trench condition in both open-cut and tunnel applications. Design for most critical groundwater level condition. Pipe design conditions:

1. Working pressure = 150 psi.
 2. Hydrostatic field test pressure = 150 psi.
 3. Maximum pressure due to surge = 225 psi.
 4. Minimum Pressure due to surge = -10 psi.
 5. Design tensile stress due to surge or hydrostatic test pressure: No greater than 50% minimum yield.
 6. Design bending stress due to combined earth loads and surge or hydrostatic test pressure: No greater than 48,000 psi.
 7. Unit weight of fill 2' 120 pcf.
 8. Deflection lag factor (DI) = 1.2.
 9. Bedding constant (K) = 0.1.
 10. Moment coefficient = 0.16.
 11. Fully saturated soil conditions $h_w = h = \text{depth of cover above top of pipe}$.
- F. Hydrostatic Test of Pipe: AWWA C 151, Section 5.2.1, at point of manufacture. Hold test for a minimum 2 minutes for thorough inspection of pipe. Repair or reject pipe revealing leaks or cracks.
- G. Pipe Manufacturer for large diameter water lines: Minimum of 5 years of successful pipe installations in continuous service. Manufacturer must maintain on site or in plant enough fittings to satisfy the following requirements:

Line Diameter	Required Bends*
20 and 24 inches	Four 45° bends per 5,000 LF of water line
> 24 inches	Four 22.5° bends per 10,000 LF of water line

*Based on total length of contract (minimum of four). Any combination of bends may be substituted at manufacturer's option (i.e. two 22.5° bends are equivalent to one 45° bend) and will be counted as one fitting.

Manufacturer or supplier must be capable of delivering bends to job site within 12 hours of notification. Use fittings at direction of Project Manager where unforeseen obstacles are encountered during construction. These fittings are in addition to any fittings called out in construction documents and must be available at all times.

- H. Provide flange adapter with insulating kit as required when connecting new piping to existing piping and piping of different materials, unless otherwise approved by Project Manager.
- I. Clearly mark pipe section to show location and thickness/pressure class color coded.
- J. No welding will be permitted on Ductile Iron Pipe except at restrained joint spigots or fittings as per ANSI/AWS D11.2. No field welding is allowed.

2.02 JOINTS

- A. Joint Types: ANSI A 21.11 push-on; ANSI A 21.11 mechanical joint; or ANSI A 21.16 flanged end. Provide push-on joints unless otherwise indicated on the Drawings or required by these specifications.
 - 1. For sanitary sewer lines with bolted joints, conform to requirements of AWWA C111; provide minimum 304 stainless steel for restraint joints.
 - 2. For water lines with bolted joints, conform to requirements of AWWA C111; provide Denso or approved equal petrolatum based tape coating system for exposed portion of nuts and bolts.
- B. Where required by Drawings, provide approved restrained joints for buried service. Refer to City's List of Approval Products for approved joint restraint mechanisms.
- C. Threaded or grooved-type joints which reduce pipe wall thickness below minimum required are not acceptable.
- D. Provide for restrained joints designed to meet test pressures required under Section 02515 - Hydrostatic Testing of Pipelines or Section 02532 - Sanitary Sewer Force Mains, as applicable. Provide restrained joints for test pressure or maximum surge pressure as specified, whichever is greater for water lines. Do not use passive resistance of soil in determining minimum restraint lengths.
- E. Electrical Bond Wires: Bond Wires; use stranded, copper cable furnished with high molecular weight polyethylene insulation (HMWPE). Use wire gauge (AWG) as shown on Drawings.

- F. Make curves and bends by deflecting joints. Do not exceed maximum deflection recommended by pipe manufacturer for pipe joints or restraint joints. Submit details of other methods of providing curves and bends for consideration by Project Manager. When other methods are deemed satisfactory, install at no additional cost to City.

2.03 GASKETS

- A. Furnish, when no contaminant is identified, plain rubber (SBR) gasket material in accordance with ANSI A21.11 or ASTM F 477; for flanged joints 1/8-inch-thick gasket in accordance with ANSI A 21.15.
- B. For pipes to be installed in potentially contaminated areas, see Specification Section 02105 – Chemical Sampling and Analysis.
- C. For Pipes to be installed in any other contaminated areas, use gaskets as recommended by the Pipe Manufacturer, Engineer of the Record and approved by City Engineer prior to installation.

2.04 FITTINGS

- A. Use fittings of same size as pipe. Reducers are not permitted to facilitate an off-size fitting. Reducing bushings are also prohibited. Make reductions in piping size by reducing fittings. Line and coat fittings as specified for pipe they connect to.
- B. Push-on Fittings: ANSI A 21.10; ductile iron ANSI A 21.11 joints, gaskets, and lubricants; pressure rated at 250 psig.
- C. Flanged Fittings: ANSI 21.10; ductile iron ANSI A 21.11 joints, gaskets, and lubricants; pressure rated at 250 psig.
- D. Mechanical Joint Fittings: ANSI A 21.11; pressure rated at 250 psi.
- E. Ductile Iron Compact Fittings: Shall conform to AWWA C153 and shall be:
 - 1. Fusion bonded epoxy lined or
 - 2. Cement mortar lined.
- F. For tangential flanged outlets shown on Drawings, substitute with a tee with an equivalent sized outlet unless otherwise approved by Project Manager.

2.05 COATINGS AND LININGS

- A. Water line Interiors: ANSI A21.4, cement lined with seal coat; ANSI A 21.16 fusion bonded epoxy coating for interior; comply with NSF 61.
- B. Sanitary Sewer and Force Main Interiors:

1. Preparation: Commercial blast cleaning conforming to SSPC-SP6.
 2. Liner thickness: Nominal 40 mils, for pipe barrel interior; minimum 6 to 10 mils at gasket groove and outside spigot end to 6-inches back from end.
 3. Testing: ASTM G 62, Method B for voids and holidays; provide written certification.
 4. Acceptable Lining Materials:
 - a. Provide approved virgin polyethylene conforming to ASTM D 1248, with inert fillers and carbon black to resist ultraviolet degradation during storage; heat bonded to interior surface of pipe and fittings.
 - b. Ceramic Epoxy – Protecto 401 or approved equal.
- C. Sanitary Sewer Point Repair Pipe: For pipes which will be lined with high density polyethylene liner pipe or cured-in-place liner, provide cement-lined with seal coat in accordance with ANSI A 21.4. For pipes which will not be provided with named liner, provide pipe as specified in Paragraph 2.05B, Sanitary Sewer and Force Main Interiors.
- D. Exterior:
1. Encasement requirement for water lines.
 - a. Open cut construction method: Provide double wrap polyethylene encasement in accordance with AWWA C105.
 - b. Auger or casing construction method:
 - 1) Double wrap with polyethylene encasement in accordance with AWWA C105. Place circumferential wraps of tape or plastic tie straps at two-foot intervals along the barrel of the pipe, and thoroughly seal each end of the polyethylene tube.
 2. Sanitary Sewers: Prime coat and outside asphaltic coating conforming to ANSI A21.10, ANSI A21.15, or ANSI A21.51 for pipe and fittings in open cut excavation and in casings.
- E. For buried sanitary sewer pipes not cathodically protected, provide polyethylene wrap unless otherwise specified or shown. Conform to requirements of AWWA C105.
- F. For flanged joints in buried service, provide petrolatum wrapping system, Denso, or equal, for the complete joint and alloy steel fasteners. Alternatively, sanitary sewer lines may use bolts made of Type 304 stainless steel.
- G. Pipe to be installed in potentially contaminated areas shall have coatings and linings recommended by the manufacturer for maximum resistance to the contaminants identified in the Phase II Environmental Site Assessment Report. If no alternative coating is specified for

water lines, provide polyethylene wrap in potentially contaminated areas.

2.06 MANUFACTURERS

- A. Use pre-approved manufacturers listed in City of Houston approved products.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Conform to installation requirements of Sections 02511 - Water Lines, 02531 - Gravity Sanitary Sewers, 02532 - Sanitary Sewer Force Mains 02631 - Storm Sewers and 02553 - Point Repairs and Obstruction Removal, except as modified in this Section.
- B. Install in accordance with AWWA C 600 and manufacturer's recommendations.
- C. Install double wrap polyethylene encasement in conformance with requirement of AWWA C105.
- D. Holiday Testing.
 - 1. Fusion Bonded Epoxy: Conform to requirements for new fittings in ANSI A 21.16.
- E. Provide electrical continuity bonding across buried mechanical and push-on joint assemblies, except where insulating flanges are required by Drawings.
 - 1. Provide minimum number of bond wires shown on Drawings. Remove one inch of HMWPE insulation from each of bond wire prior to attaching.
 - 2. Secure wire onto pipe using approved Thermite Welding procedures.
 - 3. Coat bare metal and weld metal after weld is secure. Use coal-tar compound or other compatible coating. For polyurethane coated pipe, use compatible polyurethane coating.
 - 4. Visually inspect Thermite Weld connections for electrical continuity, strength and suitable coating prior to backfilling or placing pipe in augered hole or casing.

3.02 FIELD REPAIR OF COATINGS

- A. Fusion Bonded Epoxy: Conform to requirements for new fittings in ANSI A 21.16.

END OF SECTION

SECTION 02504

FIBERGLASS REINFORCED PIPE

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Fiberglass reinforced (FRP) pipe for sanitary sewers.

1.02 MEASUREMENT AND PAYMENT

- A. Unit Prices.

- 1. No separate payment will be made for fiberglass pipe under this Section. Include cost in unit price for Work, as specified in Section 02531 - Gravity Sanitary Sewers, Section 02532 - Sanitary Sewer Force Mains, or Section 02550 - Sliplining Sanitary Sewers.
- 2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

- B. Stipulated Price (Lump Sum). If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.03 REFERENCES

- A. ASTM D 3262 - Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting- Resin) Sewer Pipe.
- B. ASTM D 3681 - Method for Determining Chemical Resistance of "Fiberglass" (Glass-Fiber- Reinforced Thermosetting-Resin Pipe in a Deflected Condition.
- C. ASTM D 3754 - Standard Specification for "Fiberglass" (Glass-Fiber Reinforced Thermosetting- Resin) Sewer and Industrial Pressure Pipe.
- D. ASTM D 3839 – Standard Guide for Underground Installation of “Fiberglass” (Glass-Fiber Reinforced Thermosetting-Resin) Pipe
- E. ASTM D 4161 - Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting- Resin) Pipe Joints Using Flexible Elastomeric Seals.
- F. ASTM F 477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
- G. AWWA Manual of Practices M45 Fiberglass Pipe Design

1.04 SUBMITTALS

- A. Conform to requirements of Section 01330 - Submittal Procedures.
- B. Provide sufficient data for the Project Manager to properly evaluate the pipe.
- C. Product data submittals shall include the following, as a minimum:
 - 1. Details of the proposed pipe.
 - 2. Properties and strengths of the pipe.
 - 3. Details of pipe joint.
 - 4. Pipe design calculations per AASHTO LRFD Bridge Design Specifications or AWWA Manual of Practice M45 are required for each pipe location and are to be signed and sealed by a licensed engineer.
 - 5. Instruction on storage, handling, transporting, and installation.
 - 6. Standard catalog sheets.
- D. Test Reports: Provide test reports upon request, certifying that the pipe has been tested in accordance with and exceeds minimum requirements of ASTM D 3262 and ASTM D 3681.

PART 2 PRODUCTS**2.01 GENERAL**

- A. Provide fiberglass reinforced pipe per the City of Houston ~~Pre~~-Approved Product List.

2.02 MATERIALS

- A. Resin Systems: The manufacturer shall use only polyester resin systems with a proven history of performance in this particular application. The historical data shall have been collected from applications of a composite material of similar construction and composition as the proposed product.
- B. Glass Reinforcements: The reinforcing glass fibers used to manufacture the components shall be of highest quality commercial grade glass filaments with binder and sizing compatible with impregnating resins.
- C. Fillers: Silica sand or other suitable materials may be used.
- D. Additives: Resin additives, such as pigments, dyes, and other coloring agents, if used, shall in no way be detrimental to the performance of the product nor shall they impair

visual inspection of the finished products.

- E. Rubber Gaskets: Supply from an approved gasket manufacturer in accordance with ASTM F 477, when no contaminant is identified and suitable for the service intended. Gaskets shall either be affixed to the pipe by means of a suitable adhesive or shall be installed in such a manner so as to prevent the gasket from rolling out of the pre-cut groove in the pipe or sleeve coupling. When pipe is to be installed in potentially contaminated areas, especially where free product is found near the elevation of the proposed sewer, provide the following gasket materials for the noted contaminants.

CONTAMINANT	GASKET MATERIAL REQUIRED
Petroleum (diesel, gasoline)	Nitrile Rubber
Other Contaminants	As recommended by the pipe manufacturer, Engineer of the Record and approved by City Engineer prior to installation

1. If required gasket material is not available for use, pipe other than fiberglass pipe must be used in potentially contaminated areas in accordance with specification section 02105-Sampling and Analysis in PPCA.

- F. The internal liner resin shall be suitable for service as sewer pipe, and shall be highly resistant to exposure to sulfuric acid as produced by biological activity from hydrogen sulfide gases. Pipe shall meet or exceed requirements of ASTM D 3681.

2.03 MANUFACTURE AND CONSTRUCTION

A. Pipes

1. Furnish pipes in the diameters specified and within the tolerances specified below.
2. Manufacture pipe by the centrifugal casting process or filament winding to result in a dense, nonporous, corrosion-resistant, consistent composite structure to meet the operating conditions as shown on the Drawings.
3. Do not use stiffening ribs or rings.

- B. Couplings: Unless otherwise specified, the pipe shall be field connected with fiberglass sleeve couplings that utilize elastomeric sealing gaskets as the sole means to maintain joint watertightness. The joints must meet the performance requirements of ASTM D 4161.

- C. Fittings: Flanges, elbows, reducers, tees, and other fittings shall be capable of withstanding operating conditions when installed. They may be contact molded or manufactured from mitered sections of pipe joined by glass fiber reinforced overlays.

- D. Manhole Connections: Provide a water stop flange (wall pipe) for connection to manhole

base or other structure in accordance with Section 02081 - Cast-in-Place Concrete Manholes, or Section 02082 - Precast Concrete Manholes.

- E. Grout Ports: Provide grout ports in the wall of pipe when required. Provide plugs of 316 stainless steel or other corrosion-resistant material compatible with the pipe. Grout port plugs shall be designed and installed to meet the test pressure of the pipe.

2.04 DIMENSIONS

- A. Diameters: The actual outside diameter of the pipes shall be in accordance with Table 3 of ASTM D 3262 for gravity sewers, or ASTM D 3754 for force mains.
- B. Lengths: The pipe standard length will be approximately 20 feet. A maximum of 10 percent of the lengths, excluding special order pipes, may be supplied in random lengths.
- C. Wall Thickness: The minimum average wall thickness shall be the stated design thickness. The minimum single point thickness shall not be less than 90 percent of the stated design thickness.
- D. End Squareness: Pipe ends shall be square to the pipe axis.
- E. Tolerance of Fittings: The tolerance of the angle of an elbow and the angle between the main and leg of a wye or tee shall be plus or minus 2 degrees. The tolerance on the laying length of a fitting shall be plus or minus 2 inches.

2.05 STIFFNESS CLASSES

- A. Stiffness class of FRP pipe shall satisfy design requirements, but shall not be less than 46 psi, when used in direct bury operation; 36 psi, when installed within a primary tunnel liner.
- B. Stiffness class of FRP in a pipe jacking operation shall be governed either by the ring deflection limitations or by a pipe design providing longitudinal strength required by the jacking method and shall satisfy design requirements stated below. Submit design calculations as required in Paragraph 1.04, Submittals.
 - 1. Pipe stress calculations based on jacking loads shall be performed to conform to Section 02441 ~~— Microtunneling~~ and or Section 02445 - Pipe-Jacked and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels.
 - 2. Ring deflection calculations shall conform to design requirements of 30 TAC Chapter 317.20 pertaining to flexible pipe used in gravity sewers. The pipe deflection calculations shall ensure that predicted deflection will be less than 5 percent under long-term loading conditions (soil prism load) for the highest density of soil overburden and surcharge loads. Deflection on calculations shall be prepared using long-term (drained) values for soil parameters contained in the geotechnical investigation report for the Project, or other site-specific data obtained by the Contractor as approved by the Engineer.

2.06 TESTING

- A. Pipes shall be tested in accordance with ASTM D 3262 or ASTM D 3754, as applicable, except that the factory hydrostatic pressure testing is not required.
- B. Joints: Coupling joints shall be qualified per the tests of Section 7 of ASTM D 4161.

2.07 INSPECTION

- A. The Project Manager shall be entitled to inspect pipes or witness the pipe manufacturing. Such inspection shall not relieve the manufacturer of the responsibilities to provide products that comply with the applicable standards and these Specifications.
- B. Manufacturer's Notification: Should the Project Manager wish to see specific pipes during any phase of the manufacturing process, the manufacturer must provide the Project Manager with adequate advance notice of when and where the production of those pipes will take place.
- C. Failure to Inspect: Should the Project Manager elect not to inspect the manufacturing, testing, or finished pipes, it in no way implies approval of products or tests.

2.08 PACKAGING, HANDLING, AND SHIPPING

- A. Packing, handling, and shipping should be done in accordance with the manufacturer's recommendations.

PART 3 EXECUTION**3.01 INSTALLATION**

- A. Install pipe and fittings in accordance with requirements of Section 02531 - Gravity Sanitary Sewers, 02532 - Sanitary Sewer Force Mains, or Section 02550 - Sliplining Sanitary Sewers.
- B. The manufacturer must supply a suitable qualified field service representative to be present periodically during the installation of pipe.
- C. Pipe Bedding and backfill: Conform to requirements of Section 02317 - Excavation and Backfill for Utilities.
- D. Pipe Handling: Use textile slings.
- E. Jointing
 - 1. Clean ends of pipe and coupling components.
 - 2. Check pipe ends and couplings for damage. Correct any damage found.

3. Coupling grooves must be completely free of dirt.
 4. Apply joint lubricant to pipe ends and rubber seals of coupling. Use only lubricants approved by the pipe manufacturer.
 5. Use suitable auxiliary equipment, such as a wire rope puller, to pull joints together.
 6. Do not exceed forces recommended by the manufacturer for coupling pipe. If excessive force is required, remove coupling, determine source of problem, and correct it.
 7. In the process of jointing the pipe, do not allow the deflection angle to exceed the deflection permitted by the manufacturer.
- F. If pressure grouting of the pipe is conducted as part of a pipe-jacked tunnel installation, seal the grout holes with liner resin to a thickness equal to the pipe liner thickness or with a threaded plug for that purpose.
- G. Tests: Conform to requirements of Section 02533 - Acceptance Testing for Sanitary Sewers.

END OF SECTION

SECTION 02526

WATER METERS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Water meters, submeters, and fire service meters.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Measurement for water meters is on unit price basis for installation of each meter type and size.
2. Payment includes vault, piping and appurtenances necessary for complete installation of meter.
3. Measurement for relocating and reinstalling meter with new box is on unit price basis for each meter relocated and reinstalled.
4. No separate payment for adjustment of meter or meter box unless otherwise shown in Drawings.
5. Refer to Section 01270 - Measurement and Payment for unit price procedures.

- B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work is in this Section is included in total Stipulated Price.

1.03 REFERENCES

- A. ASME B 16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
- B. AWWA C 510 - Standard for Double Check Valve Backflow - Prevention Assembly.
- C. AWWA C 700 - Standard for Cold-Water Meters - Displacement Type, Bronze Main Case.
- D. AWWA C 701 - Standard for Cold-Water Meters - Turbine Type for Customer Service.
- E. AWWA C 702 - Standard for Cold-Water Meters - Compound Type.
- F. AWWA C 703 - Standard for Cold-Water Meters - Fire Service Type.

- G. AWWA Manual M6 - Water Meters - Selection, Installation, Testing, and Maintenance.

1.04 SUBMITTALS

- A. Conform to requirements of Section 01330 - Submittal Procedures.
- B. Submit written certification of calibration and test results.
- C. Submit manufacturer's certification that meters meet applicable requirements of this Specification Section.
- D. Submit accuracy registration test certification from manufacturer for each 3-inch through 10- inch diameter meter.

1.05 QUALITY ASSURANCE

- A. Submit manufacturer's warranty against defects in materials and workmanship for one year from date of Substantial Completion.
- B. Provide vendor's unconditional guarantee that performance of each meter meets applicable AWWA standards and AWWA Manual M6 as follows:

1. Displacement type: 10 years from installation or register registration shown below, whichever comes first.

Size (inch)	Registration (million gallons)
5/8, 3/4	1.5
1	2.5
1-1/2	5.0
2	10.5

2. Turbine type: 1 year from date of installation.
3. Compound type: 1 year from date of installation.
4. Fire service type: 1 year from date of installation.

Operations of hermetically sealed register, 5/8-inch to 2-inch diameter, shall be unconditionally guaranteed for 15 years.

- C. Provide manufacturer's unconditional guarantee for each sealed register against leakage, fogging, discoloration, and stoppage for 15 years from date of installation.
- D. Vendor may replace meters that become defective within guarantee period with meters that comply with this Specification. City will return defective meters to vendor at their expense. Meters repaired or replaced under this guarantee must meet accuracy limits for

new meters upon receipt and accuracy limits for remaining period of initial guarantee.

1.06 EASEMENT REQUIREMENTS

- A. Install 2-inch and smaller water meters and shut-off valves (stop boxes) in right-of-way when possible. Otherwise, install in a minimum 5-foot by 5-foot separate water meter easement contiguous with public right-of-way.
- B. Install 3-inch to 6-inch water meters in a minimum of 10-foot by 20-foot separate water meter easement contiguous with public right-of-way.
- C. Install 8-inch and larger water meters in a minimum of ~~10~~5-foot by 25-foot separate water meter easement contiguous with public right-of-way.
- D. Locate water meter easements contiguous with public right-of-way unless approved by Project Manager. Provide minimum fifteen foot wide access easement when not contiguous with public right-of-way.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide meters of type and size as indicated on Drawings, unless otherwise indicated.
- B. Provide bolted split casings. Main casings of meters and external fasteners: Copper alloy with minimum 75 percent copper for 5/8 inch to 2 inches, bronze or cast iron, hot-dipped galvanized or epoxy coating for 3 inches and larger.
- C. Straightening Vanes: Non-corrosive material compatible with case material.
- D. Intermediate gear train shall not come into contact with water and shall operate in suitable lubricant.
- E. Registers: Automatic Meter Reading (AMR) type that provides pulse, contact closure, piezo switch or encoder generated output signal, compatible with City's radio and telephone AMR systems. Provide minimum 12-foot wire when permanently connected to register. Lens: impact resistant. Register box: tamper resistant by means of tamper screw or plug; Register: permanently sealed, straight-reading, center-sweep test hand, magnetic driven, U.S. gallons. Digits: 6, black in color, with lowest registering 3 digits (below 1,000-gallon registration) having contrasting digit and background color. Register capacity of meters: 9.99 million gallons for 5/8 inch to 2 inches and 999.999 million gallons for 3 inches and larger.
- F. Connections: 5/8 inch to 1 inch: threads at each end; 1-1/2 to 2 inches: 2-bolt oval flanges each end; 3 inches and larger: flange at each end.

- G. Stamp manufacturer's meter serial number on outer case. Stamp manufacturer's meter serial number on outside of register lid when provided. Manufacturer's serial numbers shall be individual and not duplicated.
- H. Meters: Provide approved meters equip with AMR type register to connect to City of Houston's AMR system.
- I. Manufacturing Quality Control shall permit successful interchangeability from one meter to another of same size including registers, measuring chambers and units, discs or pistons as units, change gears, bolts, nuts, and washers without affecting accuracy of new meter.
- J. For water meter vaults provide:
 - 1. 1/4-inch steel or aluminum with stainless steel hinge pins. Door shall open to 90 degrees and automatically lock in that position.
 - 2. Provide approved meter vault covers.

2.02 METER APPLICATIONS

- A. Meter type requirements to usage application
 - 1. All meters must be compatible with the City of Houston automated meter reading (AMR) System and /or automated metering infrastructure (AMI) system
 - 2. Sizes 5/8-inch to 2-inch Meters: Displacement type excluding application exceptions notes in paragraph 2.02 A.3
 - 3. Exceptions
 - a. Meter types for sizes 1-inch to 2-inch NFPA 13-D, 13-R applications require prior approval by the City of Houston. (Displacement meters are not allowed for these applications).
 - b. Applications where constant flow is required a 2-inch turbine type meter may be substituted.
- B. Sizes 3-inch and above Meters:
 - 1. Turbines:
 - Processing plants
 - Manufacturing facilities
 - Lawn sprinkler systems
 - Effluent water in treatment plants
 - Booster (pump)stations

Level controlled tank filling operations
 Fire hydrants (transients)
 Inter-systems sale or transfer
 Sewer credit/sub-meter

2. Compounds:

Multi-family dwellings
 Motels and hotels
 Hospitals
 Schools
 Restaurants
 Office buildings
 Dormitories, nursing homes, department stores, shopping malls, and other commercial establishments

3. Fire Rated Turbines:

Open systems feeding directly from a tank

4. Fire Rated Compounds:

Combination domestic and fire services
 Open system not feeding directly from a tank

5. Electromagnetic Meters:

Inter-system sale or transfer
 Raw water
 Basement or inside structure installations
 Contract water
 Above ground applications in potential hazardous chemical environs Meters larger than 10-inch.

C. Meter size requirements to flow considerations

Meter flow range is dependent on amount of pressure and slightly varies with manufacture.

Flow Range	Max. Continuous Flow	Meter Size
1/4 - 25 GPM	15 GPM	5/8" Positive Displacement
3/4 - 70 GPM	50 GPM	1" Positive Displacement
1 1/4 - 120 GPM	80 GPM	1 1/2" Positive Displacement
1 1/2 - 170 GPM	100 GPM	2" Positive Displacement

Flow Range	Max. Continuous Flow	Meter Size
5 – 550 GPM	450 GPM	3" Turbine

15 – 1250 GPM	1000 GPM	4" Turbine
20 – 2500 GPM	2000 GPM	6" Turbine
30 – 4500 GPM	3500 GPM	8" Turbine
50 – 7000 GPM	5500 GPM	10" Turbine

Flow Range	Max. Continuous Flow	Meter Size
½ - 450 GPM	350 GPM	3" Domestic Compound
¾ - 1250 GPM	1000 GPM	4" Domestic Compound
1 – 2000 GPM	1400 GPM	6" Domestic Compound
¾ - 1200 GPM	1200 GPM	4" Fire Compound
1 ½ - 2500 GPM	2500 GPM	6" Fire Compound
2 – 4000 GPM	4000 GPM	8" Fire Compound
2 – 6500 GPM	6500 GPM	10" Fire Compound

- D. Meter location preference hierarchy for 3" and Larger applications
Outline by order of preference for Meter Easement location. Any installation other than "D1." requires approval from the Office of the City Engineer (OCE).

1. Adjacent to Public ROW
2. Not adjacent to Public ROW with water line easement.
3. Parking garage
4. Mechanical room area of basement
5. Public ROW
6. Above ground meter installations are required on potential hazardous chemical environs, and meters larger than 10".

Note: Per chapter 7 of the City of Houston Design Manual,
Install separate tap and service lead for each domestic meter. Irrigation meters are to be branched off the domestic service.

Eligibility Requirements for Meter Easement Locations

Acronym Definition:

P.A.E.- Permanent Access Easement.

A.D.A.- American's with Disabilities

Act. ROW- Right of Way.

Meter Location	Meter Easement	Water line Easement	P.A.E.	A.D.A. Requirements	Electric and Phone service	Encroachment permit	Min. Utility Spacing	Special Meter Vault, or Meter Setup Requirements
Grade Level Easement Adjacent to ROW	YES	NO	NO	NO	NO	NO	NO	NO
Grade Level Easement Not Adjacent to ROW	YES	YES	NO	NO	NO	NO	NO	NO
Parking Garage	YES	**NO	YES	NO	YES	NO*	NO	YES
Mechanical Room in Basement	YES	**NO	NO	NO	YES	NO*	NO	YES
Public ROW	NO	NO	NO	YES	NO	YES	YES	YES
Above Ground Installations	YES	**NO	YES	NO	YES	NO	NO	YES

* Provided structure does not encroach ROW

** Provided meter is set adjacent to ROW

2.03 MATERIALS

A. Cold-Water Meters:

1. Displacement Type: AWWA C 700; sizes 5/8 inch up to and including 2 inches; oscillating disc or piston of magnetic drive type; bolted split-case design, with either being removable.
2. Turbine Type: AWWA C 701; Class II; sizes 1-1/2 inches through 10 inches; flanged; straight-through measuring chamber; rotor construction: polypropylene or similar non-rubber material with specific gravity of approximately 1.0, equipped with near frictionless replaceable bearings in turbine working against rotor shaft positioned thrust bearing. Transient/Fire Hydrant Meter Inlet: Female fitting for attachment to hose nozzle with National Standard Fire hose thread. Outlet: 2-inch nipple with National Pipe Thread. Include restriction plate to limit flow through meter to 400 gpm at 65 psi. 1-1/2 inches through 8 inches are to be furnished with test plugs in the outlet port of the meter for field testing.

3. Compound Type: AWWA C 702; sizes 2 inches through 6 inches. Measuring chambers: For use in continuous operation; separate units of copper alloy (minimum 84 percent copper) or approved polymer material, inert in corrosive potable water; with centering device for proper positioning. Measuring pistons: Non-pilot type with division plates of rubber covering vulcanized to stainless steel or other approved material of sufficient thickness to provide minimum piston oscillation noise. Measuring discs: Flat or conical type, one piece, mounted on monel or 316 stainless steel spindle. Measuring chamber strainer screen area: Twice area of main case inlet.
4. Fire-Service Type: sizes 4 inches through 10 inches; turbine-type, compound type, proportional type; AWWA C 703, with separate check valve conforming to AWWA C 510. Determine size of fire meter by adding fire flow and domestic flow.

2.04 STRAINERS

- A. Displacement Potable Water Meters 5/8 inch through 2 inches: Self-straining by means of annular space between measuring chamber and external case or with strainer screens installed in meter. Provide rigid screens which fit snugly, are easy to remove, with effective straining area at least double that of main case inlet.
- B. Potable Water Meters 2-inch diameter and larger: Equip with separate external strainer with bronze body for diameters less than 8 inches. 8-inch diameter and larger may be cast iron, hot-dipped galvanized or epoxy coating. Strainers: Bolted to inlet side of meter, detachable from meter, easily removable lid. Strainer screen: Made of rounded cast bronze, stainless steel wire, having nominal screen size of 3-1/2 mesh-per-inch (U.S. Series) not less than 45 percent clear area.
- C. Provide separate approved external strainers (when required by meter manufacturer) approved for use in fire service metered connections by Underwriters Laboratories. Bodies: Cast iron or copper alloy. Ends: Flanged in accordance with ASME B 16.1, Class 125. Provide stainless steel basket. Strainers shall be detachable from meter.

2.05 CONNECTIONS AND FITTINGS

- A. Provide pipe for connections in accordance with Section 02501 - Ductile Iron Pipe and Fittings and Section 02506 - Polyvinyl Chloride Pipe. Use restrained joints and flanged joints only.
- B. Fittings:
 1. For meters 2 inches and smaller: Same type of fittings as Outlet End fittings for Curb Stop in accordance with Section 02512 - Water Tap and Service Line Installation.

2. For meters 3 inches and larger: Restrained ductile iron; push-on bell joints or mechanical joint fittings between water line and meter vault; Class 125 flanged inside meter vaults; cement mortar lined and sealed.

2.06 LAYING LENGTHS

- A. Minimum laying lengths for meter and standard strainer shall be as shown on Drawings.

PART 3 EXECUTION

3.01 TAPPING AND METER SERVICE INSTALLATION

- A. Refer to Section 02525 - Tapping Sleeves and Valves for tapping requirements.
- B. Meter Service Line:
 1. Use pipe and fittings conforming to requirements of Section 02501 - Ductile Iron Pipe and Fittings, or Section 02506 - Polyvinyl Chloride Pipe.
 2. Limit pulling and deflecting of joints to limits recommended by manufacturer.
 3. Make vertical adjustments with offset bends where room will permit. Minimize number of bends as shown on detail drawings.
 4. Provide minimum of ten pipe diameters of straight pipe length upstream and downstream of meter vault.

3.02 METER FITTING HOOKUP

- A. Support meter piping and meter, level and plumb, during installation. Support meters 3 inches and larger with concrete at minimum of two locations.
- B. Use round flanged fittings inside meter box or vault except for mechanical joint to flange adapter. Provide full-face 1/8-inch black neoprene or red rubber gasket material on flanged joints. Provide bolts and nuts made from approved corrosion-resistant material.
- C. Tighten bolts in proper sequence and to correct torque.
- D. Visually check for leaks under normal operating pressure following installation. Repair or replace leaking components.

3.03 METER BOX AND VAULT INSTALLATION

- A. Conform to requirements of Section 02085 - Valve Boxes, Meter Boxes, and Meter Vaults.
- B. Perform adjustment to existing meter in accordance with Section 02085 - Valve Boxes,

Meter Boxes, and Meter Vaults.

3.04 BASEMENT INSTALLATIONS FOR METERS

- A. All piping within meter easement inside the building in basement must be welded steel to conform to Section 02502 - Steel pipe and Fittings or restrained Ductile Iron to conform to Section 02501 - Ductile Iron pipe and Fittings. All transitions from PVC to Steel or Ductile iron must be made on the exterior side of the basement wall. All materials must be on the City approved list of materials.
 - 1. The meter piping must conform to the City of Houston detail drawings for typical meter piping arrangement.
 - 2. All pipes must be installed straight into the building.
- B. 3" and larger meter installations for basements must be the Utility Customer Service approved for billing electromagnetic meter from the City of Houston approved products list.
- C. The customer must provide a NEMA type 4 enclosure 20"H x 16"W x 10"D for the mounting and containment of the meter electronics. The 120AC receptacle and phone jack must be installed in the enclosure.
- D. The customer must provide and maintain 120AC power and phone line within five feet of the meter location.
 - 1. The 120AC power must terminate with a GFI protected receptacle and be connected to the structure's emergency back up power.
- E. The customer must provide a phone line which can be a shared phone line.
 - 1. Phone line must terminate with a phone jack inside the service rack enclosure.
- F. The customer will be required to give the City of Houston the appropriate size meter easement to conform to the City of Houston Design Manual, with a minimum 8 feet clearance between floor and ceiling.
 - 1. Meters installed in an interior room must be fitted with double doors for easy equipment access. A floor drain must be installed within the meter easement for water drainage.
 - 2. The meter must be placed on the same floor level that the service line enters the structure. The service line must enter through the wall of the building. Use link seal method for pipe penetration thru wall as shown in City of Houston Detail Drawing.
 - 3. The customer or property owner shall keep the space occupied by the meter free from rubbish or obstruction of any kind, and provide access in accordance to City of

Houston Ordinance Chapter 47.

- G. No signal from the meter will be shared, duplicated, or split for the customers use. Once the meter is installed and accepted by the City of Houston the meter, instruments, and all attachments becomes the sole property of the City of Houston.

3.05 CONTRACT METER INSTALLATIONS

- A. All contract potable water and raw water accounts are required to install the Utility Customer Service approved for billing electromagnetic meter from the City of Houston approved product list.
1. With exception of Emergency Backup System meters EBS which will be the approved mechanical type meter for the application.
- B. All meter vaults must be designed to the City of Houston standard detail drawings.
1. Meter installations larger than 10" that cannot be installed within the standard City vault, or meter installations in potential hazardous chemical environs must be installed above ground.
 2. The City of Houston Engineer's office and the Meter Shop must approve an above ground meter installation.
 3. All above ground meter installations must be painted to City of Houston specifications Section 02527 - Polyurethane Coatings on Steel or Ductile Iron Pipe and have freeze protection.
 4. Above ground meter installations must have an 8'tall perimeter fence with a gate when it is not inside a water plant facility.
- C. All meter installations require meter easements and require a water line easement when meter easement is not adjacent to the City of Houston Right of Way.
1. All meters that are not located adjacent to the Public Right of Way must have an all weather hard surface road to the meter location.
- D. All contract account customers must supply 120 AC voltage with a GFI receptacle and phone service with phone jack to be terminated in a NEMA type 4 enclosure 20"H x 16"W x 10"D at the meter location.
1. Electrical service to the City of Houston meter station must be connected to the back up generator when installed within the districts plant facility.
 2. 1" PVC electrical conduit must be installed from the enclosure to the meter for the meter electronics.

Note: No customer will be allowed to share, spilt, duplicate, or disrupt any signal generated from the City of Houston meter.

3.06 TESTING

A. Accuracy registration tests will be conducted in accordance with latest revision of AWWA standard for type and size of meter.

1. Tests will be run by City of Houston on meters prior to installation at City's meter repair shop. Meters 2-inches and smaller will be tested at random at City's discretion. All 3 inches and larger meters will be tested.
2. Accuracy of displacement meters during guarantee period shall be as follows:
 - a. Initial period: of 18 months from date of shipment or 12 months from date of installation: 98.5% to 101.5% at standard and minimum flow rates; 98% to 101% at low flow rates.
 - b. Second period: AWWA new meter accuracy as tested below.

Meter Size (inches)	<u>GUARANTEE PERIOD</u>		<u>TEST FLOW RATE</u>
	Age of Meter Years	Or Million* Gallons	
5/8	>1 to <5	0.5	1/4
1	>1 to <5	1.0	3/4
1-1/2	>1 to <5	2.5	1-1/2
2	>1 to <5	5.5	2

* Total registration.

- c. Third period: AWWA new meter accuracy for standard flow rates and AWWA repair meter accuracy for minimum flow rate as tested below.

Meter Size (inches)	<u>GUARANTEE PERIOD</u>		<u>TEST FLOW RATE</u>	
	Age of Meter Years	or Million* Gallons	Standard Flow Rates (gpm)	Minimum Rate (gpm)
5/8	>5 to <10	1.5	2-15	1/4
1	>5 to <10	2.5	4-40	3/4
1-1/2	>5 to <10	5.0	8-50	1-1/2
2	>5 to <10	10.0	15-100	2

* Total registration.

3. Minimal acceptable accuracy in percent of low flow registration for turbine meters:

<u>Meter Size</u> (inches)	<u>Minimum Flow</u> (gpm)	<u>% Accuracy Required</u>
2	3	95
3	5	95
4	15	95
6	20	95
8	20	95
10	30	95

END OF SECTION

SECTION 02508

EXTRA STRENGTH CLAY PIPE

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Extra strength vitrified clay pipe for direct burial.
- B. Vitrified clay pipe for jacking and microtunneling.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

- 1. No separate payment will be made for extra strength vitrified clay pipe under this section. Include cost in unit price work, as specified in the following sections:

a. Section 02441 - Microtunneling

a.b. ~~and Pipe Jacked Tunnels~~ Section 02445 - Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels.

b.c. Section 02531 - Gravity Sanitary Sewers.

- 2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

- B. Stipulated Price (Lump Sum). If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.03 REFERENCES

- A. ASTM C 12 - Practice for Installing Vitrified Clay Pipe Lines.
- B. ASTM C 301 - Test Methods for Vitrified Clay Pipe.
- C. ASTM C 425 - Specification for Compression Joints for Vitrified Clay Pipe and Fittings.
- D. ASTM C 700 - Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated.
- E. ASTM C 828 - Test Method for Low-Pressure Air Test of Vitrified Clay Pipe Lines.
- F. ASTM C 1091 - Standard Test Method for Hydrostatic Infiltration Testing of Vitrified

Clay Pipe Lines.

- G. ASTM C 1208 - Standard Specification for Vitrified Clay Pipe and Joints for Use in Microtunneling, Sliplining, Pipe Bursting, and Tunnels.
- H. ASTM D 1784 - Standard Classification System and Basis for Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
- I. National Clay Pipe Institute (NCPI) – Vitrified Clay Pipe Engineering Manual.

1.04 SUBMITTALS

- A. Conform to requirements of Section 01330 - Submittal Procedures.
- B. Submit complete product data for pipe, fittings, gaskets and couplings for approval. Indicate conformance to appropriate reference standards.
- C. Submit certificates by a testing laboratory, hired and paid by the manufacturer, that clay pipes meet applicable standards when tested in accordance with ASTM C 301.

PART 2 PRODUCTS

2.01 VITRIFIED CLAY PIPE

- A. Vitrified clay pipe for direct burial shall conform to ASTM C 700 requirements for extra strength clay pipe.
- B. Approved manufacturers of extra strength clay pipe are:
 - 1. Mission Clay Products Corporation
 - 2. Dickey Company.

2.02 JOINTS

- A. Joints for extra strength vitrified clay shall conform to ASTM C 425.
 - 1. For clay pipe 21 inches in diameter and larger, conform to requirements for compression joints for bell-and-spigot pipe.
 - 2. For clay pipe 18 inches in diameter and smaller, conform to requirements for compression couplings for plain-end pipe.
- B. Joints for jacking, sliplining, and microtunneling pipe shall conform to ASTM C 1208.

2.03 GASKETS

- A. When no contaminant is identified, furnish rubber or polyurethane elastomer gasket material conforming to standards listed above.
- B. Pipe to be installed in potentially contaminated areas, especially where free product is found near the elevation of the proposed sewer, shall have the following gasket material for the noted contaminants:

<u>CONTAMINANT</u>	<u>GASKET MATERIAL REQUIRED</u>
CONTAMINANT	GASKET MATERIAL REQUIRED
Petroleum (diesel, gasoline)	Nitrile Rubber
Other contaminants	As recommended by the pipe manufacturer, Engineer of the Record and approved by City Engineer prior to installation

2.04 COMPRESSION COUPLINGS

- A. The PVC collar material for compression couplings of plain-end pipe shall conform to requirements of ASTM D 1784, Class 12454-B.
- B. Couplings for microtunneling and other pipe jacking methods shall be made with Type 316 stainless steel sleeve couplings that utilize elastomeric sealing gaskets as the sole means to maintain joint watertightness. The joints shall have the same outside diameter as the pipe so when the pipes are assembled, the joints are flush with the pipe outside surface.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Conform to installation requirements of:
- 1) Section 02531 - Gravity Sanitary Sewers; and
- ~~4) Section 02441 - Microtunneling or Section 02445 - Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels~~
Section 02441 - Microtunneling and Pipe Jacked Tunnels and Section 02531 - Gravity Sanitary Sewers.
- 2)
- ~~A.B.~~ Install pipe in accordance with ASTM C 12, the NCPI Vitrified Clay Pipe Engineering Manual, and manufacturer's recommendations.

3.02 ACCEPTANCE TESTING

- A. Perform acceptance testing in accordance with Section 02533 - Acceptance Testing for Sanitary Sewer, and ASTM C 1091. Do not use procedures from ASTM C 828 unless authorized by Project Manager.

3.03 FIELD QUALITY ASSURANCE

- A. The City may run tests on field samples following applicable ASTM standards at an independent laboratory to verify the required physical properties and characteristics of supplied materials. Provide product samples as requested by Project Manager.

END OF SECTION

SECTION 02509

FIBERGLASS REINFORCED PIPE FOR PRESSURE MAINS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Fiber Reinforced Pipe for buried water lines up to 30 inches in diameter, unless otherwise approved by Project Manager.
- B. Fiber Reinforced Pipe for buried sanitary sewer force mains up to 16 inches in diameter, unless otherwise approved by Project Manager.

1.02 MEASUREMENT AND PAYMENT

- A. Unit Prices.
 - 1. No separate payment will be made for fiberglass pipe under this Section. Include cost in unit price for Work, as specified in Section 02511 - Water Lines and Section 02532 - Sanitary Sewer Force Mains.
 - 2. Refer to Section 01270 - Measurement and Payment for unit price procedures.
- B. Stipulated Price (Lump Sum). If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.03 REFERENCES

- A. AASHTO - Standard Specifications for Highway Bridges.
- B. AREMA - Manual of Railway Engineering, Volume B, Chapter 15.
- C. ASTM D696 - Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30°C and 30°C with a Vitreous Silica Dilatometer
- D. ASTM D 2412 - Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
- E. ASTM D 2992 - Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting) Resin Pipe and Fittings.
- F. ASTM D 2996 - Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
- G. ASTM D 3262 - Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe.

- H. ASTM D 3681 - Standard Test Method for Chemical Resistance of “Fiberglass” (Glass-Fiber- Reinforced Thermosetting-Resin) Pipe in a Deflected Condition.
- I. ASTM D 3754 - Standard Specification for “Fiberglass” (Glass-Fiber Reinforced Thermosetting-Resin) Sewer and Industrial Pressure Pipe.
- J. ASTM D 4161 - Standard Specification for “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals.
- K. ASTM F 477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
- L. AWWA C 950 – Fiberglass Pressure Pipe
- M. AWWA M 45 – Fiberglass Pipe Design
- N. ISO 14692 – Petroleum and Natural Gas Industries – Glass-Reinforced Plastics (GRP) Piping
- O. NSF Standard 61 - Drinking Water System Components - Health Effects.

1.04 SUBMITTALS

- A. Conform to requirements of Section 01330 - Submittal Procedures.
- B. Provide sufficient data for the Project Manager to properly evaluate the pipe.
- C. Product data submittals shall include the following, as a minimum:
 - 1. Details of the proposed pipe.
 - 2. Properties and strengths of the pipe.
 - 3. Details of pipe joint.
 - 4. Pipe design analysis and thrust restraint calculations in accordance with AWWA M45 – Fiberglass Pipe Design, latest edition.
 - 5. Instruction on storage, handling, transporting, and installation.
 - 6. Standard catalog sheets.
- D. Test Reports: Provide test reports upon request, certifying that the pipe has been tested in accordance with and exceeds minimum requirements of ASTM D 2412, ASTM D 2992 (if applicable), D 3262 and ASTM D 3681.
- E. Certification from manufacturer that fiberglass pipe was hydrostatically tested at factory in accordance with AWWA C 950 and requirements of this section.
 - 1. Hydrostatic Test Pressure: 150 psi

2. Test Duration: Two (2) minutes
- F. An affidavit of compliance stating that all delivered materials comply with the requirements of these specifications as well as compliance with AWWA C950.
- G. For pressure mains 24-inches in diameter and larger, shop drawings signed and sealed by Professional Engineer registered in State of Texas showing:
 1. Manufacturer's pipe design calculations including thrust restraint design.
 2. Details of pictorial nature of critical features and specials indicating alignment and grade, laying dimensions, fabrication, fitting, flange, and fully dimensioned details, with plan view detailing pipe invert elevations, bends, and other critical features. Indicate station numbers for fittings corresponding to Drawings. Do not start production of pipe and fittings prior to review and approval by Project Manager. Provide final approved lay schedule on CD-ROM in Adobe Portable Document Format (*.PDF).
 3. Certification from manufacturer that design was performed for project in accordance with requirements of this section. Certification to be signed and sealed by Professional Engineer registered in State of Texas.

1.05 QUALITY CONTROL

- A. Manufacturer to provide permanent quality control department and laboratory facility capable of performing inspections and testing as required by Specifications. Material testing, inspection procedures, and manufacturing process are subject to inspection by Project Manager. Perform manufacturer's tests and inspections required by referenced standards and these Specifications.
- B. Calibrate within last 12 months equipment such as scales, measuring devices, and other calibration tools used in manufacture of pipe. Affix tag recording date of last calibration on each device used in manufacture of pipe.

1.06 TESTING

- A. Joints: Coupling joints shall be qualified per the tests of Section 7 of ASTM D4161.
- B. Provide pipes tested in accordance with AWWA C950 and ASTM D 3754 as applicable.
- C. Hydrostatic Testing: AWWA C950, Section 5.1.2.1.1, at point of manufacture. Hold test for minimum 2 minutes for thorough inspection of pipe. Reject pipe revealing leaks or cracks.

PART 2 PRODUCTS

2.01 FIBERGLASS PIPE

- A. Manufacture pipe by filament winding process to result in a dense, nonporous, corrosion-

resistant, consistent composite structure to meet the operating conditions as shown on the Drawings.

1. Do not use stiffening ribs or rings.
2. The workmanship of the pipe shall be free of defects such as delaminations, indentations, pinholes, bubbles, cracks, pits, blisters, foreign inclusions, and resin-reduced areas. Reasons for these defect free workmanship is because of the serviceability and strength of the pipe could be compromised.
3. The pipe must be as uniform as commercially practicable in opacity, color, density as well as other physical properties.
4. Centrifugally cast fiberglass pipe may be used in lieu of filament-wound for pressure pipe with approval of Project Manager, however, this substitution will not be approved for water lines.

B. Furnish pipes in the diameters specified and within the tolerances specified below.

1. Tolerances:
 - a. Sanitary Sewer Force Mains: Diameter tolerances in accordance with AWWA C950.
 - b. Water Mains: Diameter tolerances in accordance with AWWA C950 for diameters up to 30 inches.

C. Lengths: Supply at least 90 percent of total footage of each size and class of pipe, excluding special order pipes in nominal lengths of 20 feet unless approved by Project Manager. No nominal lengths of less than four (4) feet may be used.

D. Wall Thickness: Provide minimum average wall thickness of stated design thickness. Provide minimum single point thickness not be less than 98 percent of stated design thickness for sanitary sewer applications and not less than 100 percent for water mains.

E. End Squareness: Provide pipe ends square to pipe axis with maximum tolerance of 1/8 inch.

F. Refer to list of Approved Products for acceptable manufacturers.

2.02 DESIGN CRITERIA

A. Design fiberglass pressure pipe according to AWWA Manual M 45 – Fiberglass Pipe Design, latest edition.

B. Sanitary Sewer Force Mains:

1. Provide minimum 150 psi Pressure Class. Stiffness class of FRP pipe shall satisfy design requirements, but shall not be less than 46 psi, when used in direct bury operation; 36 psi, when installed within a primary tunnel liner.
2. Pipe for Jacking: Govern stiffness class of FRP in a pipe jacking operation by either ring deflection or by a pipe design providing longitudinal strength required by the jacking method and shall satisfy design requirements stated below. Submit design calculations as required in Paragraph 1.04, Submittals.
 - a. Perform pipe stress calculations based on jacking loads to conform to ~~Section 02441—Microtunneling and Pipe Jacked Tunnels~~Section 02441 - Microtunneling or Section 02445 - Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels
3. Calculate pipe deflection to ensure that predicted deflection will be less than 5 percent under long-term loading conditions (soil prism load) for the highest density of soil overburden and surcharge loads. Prepare deflection on calculations using long-term (drained) values for soil parameters contained in the geotechnical investigation report for the Project, or other site-specific data
4. Provide dual-angle, filament-wound fiberglass reinforced epoxy pipe with integral epoxy liner and exterior coating in sizes from 4-inch to 16-inch diameter. Conform to requirements of ASTM D 2996, depending on size and class of pipe required.
5. Hydrostatic design value shall be not less than 21,000 psi when tested in accordance with ASTM D 2992(B) and not less than 8000 psi when tested according to ASTM D 2992(A).
6. Burial depths for pipes with standard wall thickness shall be between 3 feet and 25 feet.
7. Joints: Heavy duty threaded coupling system with positive O-ring seals. For 4-inch through 6-inch diameters, provide mechanical joints with fast advance, acme-type threads. Male threaded portion of couplings shall lock the mechanical joints for couplings for pipe diameters of 8 inches through 16 inches. Axial movement of couplings shall allow up to 2 degrees of angular deflection without affecting O-ring seal integrity.
8. Pipes, fittings, and other components in this system shall be rated for service to 150 psig at 120 degrees F. Components shall be rated at or above design pressure of system.

- C. Water Lines. At minimum, provide 150 psi Pressure Class and 46 psi Stiffness Class. Manufacturer to provide calculations in accordance with AWWA M 45 to determine the appropriate pressure class and stiffness class to withstand actual installation conditions, based on the following Design Criteria:

1. Working Pressure: 150 psi.
2. Hydrostatic Field Test Pressure: 150 psi.
3. Maximum Pressure Due to Surge: 225 psi.
4. Minimum Pressure Due to Surge: -10 psi
5. Unit Weight of Soil: 120 pcf.
6. Bedding constant (K) = 0.1.
7. Deflection lag factor (DI) = 1.3
8. Minimum Trench Width: O.D. of pipe + four (4) feet.
9. Maximum allowable long term deflection not to exceed 5 percent of original pipe diameter.
10. Design:
 - a. Design to withstand most critical simultaneous application of external loads including construction loads and internal pressures.
 - b. Base on minimum of AASHTO HL-25 loading, AREMA Cooper E-80 loads when under railroads, and depths of bury as indicated.
 - c. Calculate earth loads and thrusts for restrained (tied) joints based on AWWA M45.
 - d. Groundwater Level: Assume groundwater elevation at ground surface.
 - e. Design pipe for buried conditions.

- D. Tunnel and Augered Sections: Exclude structural benefits associated with primaryliner. Design pipe and pipe joints to carry loads including but not limited to: Overburden and lateral earth pressures, subsurface soil, grouting, other conditions of service, thrust of jacks, and stress anticipated during handling and installation. Do not create grout holes with pipe.

2.03 MATERIALS

- A. Resin Systems: The manufacturer shall use only polyester resin systems with a proven history of performance in this particular application. The historical data shall have been collected from applications of a composite material of similar construction and composition as the proposed product.
- B. Glass Reinforcements: The reinforcing glass fibers used to manufacture the components shall be of highest quality commercial grade glass filaments with binder and sizing compatible with impregnating resins.

- C. Fillers: Silica sand or other suitable materials may be used.
- D. Additives: Resin additives, such as pigments, dyes, curing agents, thixotropic agents, and other coloring agents, if used, shall in no way be detrimental to the performance of the product nor impair visual inspection of the finished products.
- E. Internal Liner Resin:
 - 1. Water Lines: Manufacture using materials meeting NSF 61. Any material used within the pipe must comply with requirements of the Safe Drinking Water Act and other federal requirements. If transporting potable water, fiberglass pipe must be evaluated and certified for this specific use. The mark or seal of the laboratory that is responsible for evaluating the pipe must be included on the pipe.
 - 2. Sanitary Sewer Force Mains: Fiberglass pipe shall have resin-rich liner of following thickness:
 - a. For nominal sizes 4 inches through 6 inches, conform to ASTM D 2996 RTRP 11CX 5430, with minimum liner thickness of 0.020 inch.
 - b. For nominal sizes 8 inches through 16 inches, conform to ASTM D 2996 RTRP 11FX 3210, with minimum liner thickness of 0.025 inch.
 - c. The coefficient of linear thermal expansion shall be 8.5×10^{-6} inch/inch/degrees F for 4-inch through 6-inch pipe and 12.0×10^{-6} inch/inch/degrees F for 8-inch through 16-inch pipe in accordance with ASTM D 696.

2.04 JOINTS

- A. Gasketed Joints: Unless otherwise specified, field connect pipe with fiberglass sleeve couplings or confined o-ring bell-and-spigot joints that utilize elastomeric sealing gaskets as sole means to maintain joint water tightness. Joints shall meet performance requirements of ASTM D 4161.
 - 1. Supply rubber gaskets from an approved gasket manufacturer in accordance with ASTM F 477, when no contaminant is identified and suitable for the service intended. Affix gaskets to pipe by means of a suitable adhesive, or install in such a manner so as to prevent the gasket from rolling out of the pre-cut groove in the pipe or sleeve coupling.
 - 2. When pipe is to be installed in potentially contaminated areas, provide the following gasket materials for the noted contaminants.

CONTAMINANT	GASKET MATERIAL REQUIRED
Petroleum (diesel, gasoline)	Nitrile Rubber (for sanitary sewers) Viton (FKM) (for water lines)
Other Contaminants	As recommended by the pipe manufacturer

3. If required gasket material is not available for use, pipe other than fiberglass pipe must be used in potentially contaminated areas.
- B. Restrained Joints: Utilize locking or butt-and-wrap (laminated) joints capable of withstanding internal pressure and longitudinal tensile loads.
1. Design restrained joint pipe using the allowable stress for combined biaxial loading determined in accordance with the trapezoidal design envelope design procedure of ISO 14692, latest edition. Provide test results or other verification of joint and thrust pipe design for approval by Project Manager with submittal of pipeline layout drawings.
 2. Provide butt-and-wrap joints where restrained joints are called out on 66-inch diameter and larger.
 3. Butt-and-Wrap Joints: Provide fiberglass reinforced overlay build up of minimum dimensions of 4 inches by 6 inches around circumference joints located at thrust source and sections of pipe located within thrust restraint limits.
 4. Biaxial Lock Joint: Joints shall consist of plastic bar(s) inserted into circumferential void(s) around rubber gasket joint. Circumferential void is formed by matching recessed grooves on bell and spigot. Bar(s) shall fill void, forming an interference fit with bell and spigot to prevent joint from separating. Joint water-tightness is provided by joint gasket.
 5. If centrifugally cast fiberglass pipe is provided with approval from Project Manager, and approved restrained joints are not available, provide external thrust restraint system in accordance with Paragraph 3.02 – External Thrust Restraints.

2.05 FITTINGS

- A. Provide fittings for water mains capable of withstanding specified test pressures.
1. Outlets and Tees. Provide fiberglass pipe, ductile iron, or steel pipe when branch is less than 20 percent of diameter of main pipe and less than or equal to 8 inch diameter. Attach by glass reinforced overlays as approved by Project Manager.
 2. Provide ductile iron or steel pipe bends and outlets or tees greater than eight (8) inches in diameter or which are greater than 20 percent of diameter of main pipe.

- a. Use same materials (ductile iron or steel) throughout entire project.
 - b. Conform to Section 02518 - Steel Pipe and Fittings for Large Diameter Water Lines or Section 02501 - Ductile Iron Pipe and Fittings for other fittings and bends.
- B. Provide fittings for force mains capable of withstanding specified test pressures.
 - 1. Outlets and Tees. Provide fiberglass pipe or ductile iron pipe when branch is less than 20 percent of diameter of main pipe and less than or equal to 8-inch diameter. Attach by glass reinforced overlays as approved by Project Manager.
 - 2. Provide ductile iron pipe bends and outlets or tees greater than eight (8) inches in diameter or which are greater than 20 percent of diameter of main pipe.
 - a. Use same materials (ductile iron) throughout entire project.
 - b. Conform to Section 02501 - Ductile Iron Pipe for other fittings and bends.
- C. Fiberglass Pipe Fittings. Created by filament-winding or cut and miter process as described in AWWA M 45.
 - 1. Provide tolerance of angle of elbow and angle between main and leg of wye or tee to plus or minus 2 degrees. Provide tolerance on laying length of fitting to plus or minus 2 inches.

2.06 INSPECTION

- A. The Project Manager shall be entitled to inspect pipes or witness the pipe manufacturing. Such inspection shall not relieve the manufacturer of the responsibilities to provide products that comply with the applicable standards and these Specifications.
- B. Manufacturer's Notification: Should the Project Manager wish to see specific pipes during any phase of the manufacturing process, the manufacturer must provide the Project Manager with adequate advance notice of when and where the production of those pipes will take place.
- C. Failure to Inspect: Should the Project Manager elect not to inspect the manufacturing, testing, or finished pipes, it in no way implies approval of products or tests.

2.07 PACKAGING, HANDLING, AND SHIPPING

- A. Packing, handling, and shipping should be done in accordance with the manufacturer's recommendations.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install pipe and fittings in accordance with requirements of Section 02511 – Water Lines or 02532 - Sanitary Sewer Force Mains.
- B. The manufacturer must supply a suitable qualified field service representative to be present periodically during the installation of pipe.
- C. Pipe Bedding: Conform to requirements of Section 02317 - Excavation and Backfill for Utilities.
- D. Pipe Handling: Use textile slings.
- E. Jointing:
 - 1. Clean ends of pipe and coupling components.
 - 2. Check pipe ends and couplings for damage. Correct any damage found.
 - 3. Coupling grooves must be completely free of dirt.
 - 4. Apply joint lubricant to pipe ends and rubber seals of coupling. Use only lubricants approved by the pipe manufacturer.
 - 5. Use suitable auxiliary equipment, such as a wire rope puller, to pull joints together.
 - 6. Do not exceed forces recommended by the manufacturer for coupling pipe. If excessive force is required, remove coupling, determine source of problem, and correct it.
 - 7. In the process of jointing the pipe, do not allow the deflection angle to exceed the deflection permitted by the manufacturer.
- F. If pressure grouting of the pipe is conducted as part of a pipe-jacked tunnel installation, seal the grout holes with liner resin to a thickness equal to the pipe liner thickness or with a threaded plug for that purpose.
- G. Tests:
 - 1. Water Lines: Conform to requirements of Section 02514 – Disinfection of Water Lines and Section 02515 – Hydrostatic Testing of Pipelines.
 - 2. Sanitary Sewer Force Mains: Conform to requirements of Section 02532 – Sanitary Sewer Force Mains.

3.02 EXTERNAL THRUST RESTRAINT

- A. In areas of thrust restraint not using an approved restrained joint, such as with centrifugally cast fiberglass pipe, use one of three methods below. Submit system for approval by Project Manager.
1. Encased Design: For areas with restrained joint length of less than 20 feet from thrust source.
 - a. Provide thrust coupling as specified herein.
 - b. Use reinforced concrete to encase bend and pipe within area of thrust restraint. Encasement shall be of enough strength to accept 125% of designed pipe thrust.
 - c. Last four inches on both ends of encasement of fiberglass pipe shall be faced with minimum 1/4 inch thick rubber padding.
 - d. Locate sleeve coupling outside encased area.
 2. H-Pile Design: System design and construction to conform to Section 02465 - Drilled Shaft Foundation and to be signed and sealed by Professional Engineer in State of Texas.
 - a. Provide thrust coupling as specified herein.
 - b. Use concrete pipe support to support entire bend. Pipe supports shall have cradle with minimum 120 degree support arc. Support arcs shall be faced with minimum 1/4 inch thick rubber padding.
 - c. Unless otherwise approved by Project Manager, install driven H-piles, with minimum of twelve (12) piles per individual support [three (3) piles on pipe cross-section axis by four (4) piles on pipe flow axis configuration] under concrete pipe support. Piles shall be of enough strength and depth to accept 125% of designed pipe thrust through shear resistance.
 - d. Anchor bends to pipe support in manner to prevent over stressing fiberglass reinforced pipe.
 3. Use ductile iron or steel for fittings and pipe in thrust area, in accordance with requirements in Section 02501 - Ductile Iron Pipe and Fittings, Section 02502 - Steel Pipe and Fittings, and Section 02511 - Water Lines. Join fiberglass reinforced pipe to steel or ductile iron pipe outside of thrust area using fiberglass pipe manufacturer recommendation.

END OF SECTION

SECTION 02517

WATER LINE IN TUNNELS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Handling, transporting, and installing water line in primary liner tunnels, including invert cleanup and blocking and water line in casings that will be backfilled with concrete or grout.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment of water line installed by tunneling is by linear foot along center line of completed water line as designated on Drawings.
2. Payment for installation of water line in tunnel constructed according to Section 02425 - Tunnel Excavation and Primary Liner will be authorized by Project Manager in three parts. Pay estimates for partial payments will be made as measured above according to following schedule:
 - a. 60 percent of installation will be authorized when excavation and primary liner installation is complete.
 - b. 95 percent of installation will be authorized when water line installation and grouting is complete.
 - c. 100 percent of installation will be authorized when section successfully hydrostatically tested.
3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

- B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work is in this Section is included in total Stipulated Price.

1.03 REFERENCE STANDARDS

- A. ASME B 40.1 - Pressure Gauge and Gauge Attachments.

1.04 SUBMITTALS

- A. Submit work plan including following information in accordance with Section 01330 - Submittals.

1. Method of transporting pipes into tunnel.
2. Method of hoisting and positioning pipe in tunnel.
3. Method of jointing and aligning pipe.
4. Method of supporting and blocking pipe.
5. Tunnel ventilation while setting pipe and completing joints, when applicable.
6. Material, equipment and procedures for grout placement and other information required by Section 02431 - Tunnel Grout.

- B. Submit results of tunnel primary liner survey in accordance with Paragraph 3.02, Tunnel Survey.
- C. Submit results of installed water line survey in accordance with Paragraph 3.10, As-built Survey and Installation Tolerances.

1.05 PROCEDURES

- A. Joints: Prepare joints as recommended by pipe manufacturer and in accordance with Section 02511 - Water Lines.
- B. Handling: Handle, store, and transport pipe in accordance with pipe manufacturer's recommendations and to prevent damage to pipe ends, pipe barrel, steel reinforcement, and pipe protective linings.
- C. Grouting: Perform grouting of annular space between water line and tunnel liner to fill voids with grout, without dislocating or damaging pipe.

PART 2 PRODUCTS

2.01 ANNULAR GROUT

- A. Specified in Section 02431 - Tunnel Grout

2.02 CONCRETE

- A. Meeting requirement of Section 03315 - Concrete for Utility Construction, Class B concrete.

2.03 PIPE MATERIAL AND FITTINGS

- A. Manufacture and deliver pipe material and fittings as described in Section 02511 - Water Lines.

2.04 SPACERS

- A. Unless otherwise noted on Drawings, use casing spacers between water line and casing tunnel liner for water lines less than 24 inches in diameter. Refer to Paragraph 3.01 for exception. See Section 02447 — ~~Augering Pipe and Conduit~~ Installation of Water Lines by Slurry Bore for spacer requirements and installation.

PART 3 EXECUTION

3.01 APPLICATION

- A. Grout in place, tunnels for water lines with diameters of 36-inches or greater. When tunnel liner plate is used, grout water line in place regardless of water line diameter.

3.02 TUNNEL SURVEY

- A. Prior to installing water line in tunnel: Perform survey of tunnel in accordance with Paragraph 3.10B. Verify tunnel has been constructed within specified tolerances for line, grade, and roundness and water line to be placed in tunnel can be placed in conformance with tolerances specified. Should misalignment of tunnel preclude proper installation of water line, notify Project Manager of proposed correction method. Project Manager will make final decision on acceptability of correction.

3.03 PIPE TRANSPORT

- A. Transport pipe in tunnel for final placement so that no damage occurs to pipe ends or pipe barrel and interior lining or exterior coating. Repair pipe damaged during transport or final placement in tunnel in manner acceptable to Project Manager prior to joining. Remove damaged pipe from tunnel and replace, when directed by Project Manager, at no additional cost to City.

3.04 TUNNEL CLEANUP

- A. Remove temporary tunnel utilities, loose material, dirt, and debris prior to pipe placement. Broom clean concrete invert. Control seepage and remove standing water in invert.
- B. Temporary construction tracks or pipe skids may be left in place when they do not interfere with alignment of water line, short circuit cathodic protection system, or interfere with final placement of annular grout.

3.05 INVERT PIPE SUPPORT

- A. Construct invert pipe support of screeded concrete, steel beam, or other method, as approved, to final grade of outside of water line. Secure invert support to primary liner to prevent movement. Cure concrete support minimum of 48 hours prior to setting pipe. Maintain minimum of 4-inches clearance between outside of water line and steel beam or steel member.

3.06 JOINING PIPE IN TUNNELS

- A. Lay pipe in accordance with pipe manufacturer's recommendations, and as specified in this Section. Join pipe segments so as to properly compress gaskets and allow for correct final positioning of pipe for line and grade. Closely align pipe and bring loosely together by means of hydraulic jacks, locomotives, pipe mobiles, or winches. Once pipes have been loosely joined, pull home by means of hydraulic tugger or other similar methods suitably protecting pipe and joints against damage. Impact joining, such as ramming with locomotives or other mechanical equipment, is not permitted.

3.07 SUPPORTING PIPE IN TUNNEL AND BULKHEADS

- A. Develop and submit pipe supporting system that will prevent water line from floating and deforming beyond specified limits. Loads imposed on pipe, primary liner and surrounding soil during grouting shall be determined by Registered Professional Engineer in State of Texas. Show essential details in plan for supporting system. Position water line in tunnel to allow minimum of 4 inches of grout to be placed between water line and tunnel primary liner or casing.
- B. Wooden support blocks are not allowed.
- C. Prevent pipe from floating during backfill operations by properly installed supporting. Remove and replace segment of pipe which is distorted or moved from final line and grade.
- D. Secure supporting in place so that it cannot be dislodged during adjacent pipe laying and during grouting operations.
- E. Construct bulkheads of material, compatible with grout, to withstand imposed grout pressure without leakage. Provide bulkheads at frequency to allow completion of grouting in continuous operation and to permit timely removal of pipe and grout which may be needed as result of pipe distortion or movement. Modifications to bulkhead spacing will be reviewed by Project Manager. Provide adequate venting for bulkheads.
- F. Contractor may use mortar bands, casing spacers or blocking to support pipe in tunnel.
- G. If mortar bands are used, mortar coating must be used. Refer to Section 02518 – Steel Pipe and Fittings for Large Diameter water lines for requirements.

3.08 ANNULAR GROUT

- A. Fill annular void between water line and tunnel primary liner or casing with grout, in accordance with Section 02431 - Tunnel Grout.
- B. Test annular grout material, equipment, and procedures in accordance with approved submittal. Perform test on first 200 feet of water line to be backfilled. When grout does not totally fill annular space or other problems occur, correct defects in first test section and adjust method or mix and rerun test on next 200 feet. Repeat procedure as necessary.

C. Placement:

1. Placement Limits: Predetermine limits of each grout placement stage by size and capacity of batching equipment and initial set time of proposed grout. Under no circumstances shall placement at grout port continue longer than period of time for mix to take initial set. Locate grout hole spacing and locations according to number of stages necessary to backfill tunnel liner. Do not install another lift until proper set has been attained. Placement procedures shall be approved by admixture or additive manufacturers.
2. Equipment - Pumps: Pumping equipment must be of sufficient size and capacity to place grout to distances and volumes compatible with batching and mixing equipment. Maintain equipment and clean thoroughly each day. No hydrocarbons shall enter pumping chamber. Under no circumstances shall grout be pumped in excess of 1000 linear feet without prior approval by Project Manager. Pumping test and verification testing of resulting grout quality will be required for approval.
3. Slickline: Convey grout to point of placement in clean steel or rubber hoses designed to handle safely, pump pressure and volumes during placement. Do not allow hardened grout or concrete to obstruct or coat steel pipe or hose internally.
4. Grout Connections: Grout connections shall be sized minimum of 2-inch inside diameter, consisting of grout hose attached immediately to pressure gauge. Gauged pumping pressure shall not exceed water line manufacturer's recommendations. Monitor grout pressure.
5. Gauges:
 - a. Type: Instrument oil-filled and attached to saddle-type diaphragm seal (gauge saver) to prevent clogging with grout.
 - b. Calibration: Certified and calibrated in accordance with ASME B 40.1.
 - c. Range: Not more than 100 percent greater than design grout pressure.
 - d. Accuracy: No more than one-half percent error over full range of gauge.
 - e. Fitting: Attach gauge to valve immediately attached to grout port in tunnel liner. Provide T-fitting in injection line for sampling.
6. Limit pressure on annular space to prevent damage to pipe or liner. Define limiting and estimated required pressure range. Provide and monitor open ended, high point tap or equivalent vent at bulkhead opposite point of grouting.
7. Pump grout until grout within 5 percent of specified density discharges from end opposite injection point to ensure grout is not diluted by extraneous water in annulus.

8. Drilling of access holes from surface to facilitate grouting shall not be allowed.
 9. Communication: There shall be constant communications via telephone between headerman at point of injection and pump, batch plant, and supervisor. Under no circumstance shall grouting continue without continuity of communications.
 10. The headerman at point of placement shall advise batch plant of variations of density and make corrections as necessary. Record and submit to Project Manager for each days pour variations and corrections.
- D. Delay grouting until all significant differential movement has stopped as determined by monitoring.
 - E. Remove bulkheads unless constructed of masonry.
 - F. Repair or replace damage or distortion to water line.

3.09 GROUTING JOINTS

- A. Materials and procedures for filling interior joint recesses shall conform to Section 02511 - Water Lines.

3.10 AS-BUILT SURVEY AND INSTALLATION TOLERANCES

- A. Perform as-built survey on installed water line. Determine horizontal and vertical location for invert of each pipe joint.
- B. Acceptable tolerances: Within plus or minus 3 inches of horizontal alignment, within plus or minus 2 inches of vertical alignment.

END OF SECTION

SECTION 02611

REINFORCED CONCRETE PIPE

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Reinforced concrete pipe for sanitary sewers and storm sewers.

1.02 MEASUREMENT AND PAYMENT

- A. Unit Prices.

- 1. No separate payment will be made for reinforced concrete pipe under this Section. Include cost in unit price Work as specified in following Sections:

- a. Section 02426 - Sewer Line in Tunnels.
- b. Section 02531 - Gravity Sanitary Sewers.
- c. Section 02631 - Storm Sewers.

- 2. Refer to Section 01270- Measurement and Payment for unit price procedures.

- B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this section is included in total Stipulated Price.

1.03 REFERENCES

- A. ASTM C 76 - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
- B. ASTM C 443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
- C. ASTM C 497 - Standard Test Method for Concrete Pipe, Manhole Sections, or Tile.
- D. ASTM C 506 - Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain and Sewer Pipe
- E. ASTM C 507 – Standard Specification for Reinforced Concrete Elliptical Culverts, Storm Drains and Sewer Pipe

- F. ASTM C 655 - Standard Specification for Reinforced Concrete D-load Culvert, Storm Drain and Sewer Pipe.
- G. ASTM C 877 - Standard Specification for External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections.
- H. ASTM C 990 – Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections using Preformed Flexible Joint Sealants.
- I. ASTM C 1479 – Standard Practice for Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installations.

1.04 SUBMITTALS

- A. Conform to requirements of Section 01330 - Submittal Procedures.
- B. Submit complete product data for pipe, fittings and gaskets for approval. Indicate conformance to appropriate reference standards.
- C. Submit manufacturer's certificate that concrete pipes meet applicable standards.
- D. For jacking pipe, submit drawings and data describing grouting port design and closure procedures when required by Section 02431 - Tunnel Grout, including liner repair, as applicable.

PART 2 PRODUCTS

2.01 REINFORCED CONCRETE PIPE

- A. Conform circular reinforced concrete pipe to requirements of ASTM C 76, Class III. Conform to rubber gasket joints for sanitary sewers and storm sewers per ASTM C443 and tongue and groove joints for roadside ditch culverts with joints per ASTM C 990.
- B. Conform reinforced concrete arch pipe to requirements of ASTM C 506 for Class A-III. Joints shall conform to ASTM C 443 or tongue & groove joints shall conform to ASTM C990 with external sealing bands conforming to ASTM C 877. For roadside ditch culverts only, external sealing bands are not required.
- C. Reinforced concrete elliptical pipe, either vertical or horizontal, shall conform to requirements of ASTM C 507 for Class VE-III for vertical or Class HE-III for horizontal. Use rubber gasket joints conforming to ASTM C 877. Rubber gasket joints shall conform to ASTM C443. Tongue & groove joints shall conform to ASTM C 990 with external sealing bands conforming to ASTM C 877. For roadside ditch culverts only, external sealing bands are not required.
- D. Conform reinforced concrete D-load pipe requirements of ASTM C 655.

2.02 GASKETS

- A. When no contaminant is identified, furnish joints per Article 2.01
- B. Use the following gasket materials for pipes to be installed in potentially contaminated areas, especially where free product is found near elevation of proposed sewer:

CONTAMINANT	GASKET MATERIAL REQUIRED
Petroleum (diesel, gasoline)	Nitrile Rubber
Other Contaminants	As recommended by pipe manufacturer, Engineer of the Record and approved by City Engineer prior to installation

2.03 LINERS FOR SANITARY SEWER PIPE

- A. Reinforced concrete pipe for sanitary sewers shall be PVC lined and conform to Section 02427 - Plastic Liner for Large-Diameter Concrete Sewers and Structures.
- B. Reinforced concrete pipes to be installed in potentially contaminated areas shall have liners recommended by manufacturer as resistant to contaminants identified in Phase II Environmental Site Assessment Report.

2.04 SOURCE QUALITY CONTROL

- A. Representatives of City Engineer will inspect manufacturer's plant and casting operations as deemed necessary.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Conform to requirements of following Sections, as applicable:

1. ~~1.~~ Section 02441 - Microtunneling

~~and Pipe Jacked Tunnels.~~ Section 02445 – Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels

2.

~~2. Section 02448 – Pipe and Casing Augering for Sewers.~~

3. Section 02448 - Pipe and Casing Augering for Sewers

~~3.~~ Section 02531 - Gravity Sanitary Sewers.

~~4.~~

~~5.~~ ~~4.~~ Section 02631 - Storm Sewers.

- B. Install reinforced concrete pipe in accordance with ASTM C 1479 and manufacturer's recommendations.

END OF SECTION

SECTION 02631

STORM SEWERS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. New storm sewers and appurtenances, modifications to existing storm sewer system and installation of roadside ditch culverts.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for storm sewers, including elliptical or box storm sewer, installed by open-cut, augered with or without casing, or tunneling is on linear foot basis. Measurement for storm sewers and roadside ditch culverts will be taken along center line of pipe from center line to center line of manholes or from end to end of culverts. Measurement for storm sewer will be taken along center line of storm sewer from inside wall of storm sewer junction box when installed in conjunction with storm sewer junction box. Payment will be made for each linear foot installed complete in place, including connections to existing manholes and inlets.
2. Payment for storm sewer leads, including elliptical leads, is on a linear foot basis.
3. Payment for corrugated metal pipe storm sewer outfall, including timber bents, is on a linear foot basis.
4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

- B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.03 DEFINITIONS

- A. Long Run Culvert: A culvert which is 40 feet or more in length.

1.04 SUBMITTALS

- A. Conform to requirements of Section 01330 - Submittal Procedures.
- B. Submit manufacturer's literature for product specifications and installation instructions.
- C. Submit proposed methods, equipment, materials, and sequence of operations for sewer construction. Plan operations to minimize disruption of utilities to occupied facilities or adjacent property.

- D. For flexible pipe products, submit detailed calculations per AASHTO LRFD Bridge Design Specifications. Designs are required for each pipe location and are to be signed and sealed by a licensed engineer.

1.05 QUALITY ASSURANCE

- A. The Condition for acceptance shall be watertight storm sewer that is watertight both in pipe-to-pipe joints and in pipe-to-manhole connections.
- B. Provide manufacturer's certification to Specifications.

1.06 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Comply with manufacturer's recommendations.
- B. Handle pipe, fittings, and accessories carefully with approved handling devices. Do not drop or roll pipe off trucks or trailers. Do not use Materials cracked, gouged, chipped, dented, or otherwise damaged shall not be use materials for installation.
- C. Store pipe and fittings on heavy timbers or platforms to avoid contact with ground.
- D. Unload pipe, fittings, and appurtenances as close as practical to location of installation to avoid unnecessary handling.
- E. Keep interiors of pipe and fittings free of dirt and foreign matter.
- F. Store Thermoplastic (PVC, HDPE, PP) pipe out of direct sunlight.

PART 2 PRODUCTS

2.01 PIPE

- A. Provide piping materials for storm sewers shall be of sizes and types specified unless otherwise indicated on Drawings.
- B. In diameters where material alternatives are available, provide pipe from single manufacturer for each pipe diameter, unless otherwise approved by Project Manager or otherwise shown on Drawings.
- C. Existing pipe that has been removed during construction cannot be reused.

2.02 PIPE MATERIAL SCHEDULE

- A. Storm Sewer Pipe: Use pipe materials that conform to requirements specified in one or more of the following Sections as shown on the Drawings.
 - 1. Section 02506 - Polyvinyl Chloride Pipe. Not allowed in the following applications:

- a. Potentially Petroleum Contaminated Areas (PPCA).
 - b. Augering/ jacking.
2. Section 02505 - High Density Polyethylene (HDPE) Solid and Profile Wall Pipe and Section 02510 – Polypropylene (PP) Corrugated Wall Pipe. For use only where Storm Sewers are associated with Local Streets, where Local Street is defined by City of Houston Code of Ordinances 42-122.
 3. Section 02611 - Reinforced Concrete Pipe.
 4. Section 02612 - Precast Reinforced Concrete Box Sewers.
 5. Section 02642 - Corrugated Metal Pipe use only where Corrugated Metal Pipe is shown on Drawings.
- B. Driveway Culvert Pipe for Streets with Open Ditches: Use pipe materials conforming to requirements specified in one or more of the following Sections as shown on the Drawings.
1. Section 02505 - High Density Polyethylene (HDPE) Solid and Profile Wall Pipe and Section 02510 – Polypropylene (PP) Corrugated Wall Pipe. Use for Residential Culverts only. Use Concrete Pipe for long run culverts.
 2. Section 02611 - Reinforced Concrete Pipe.
 3. Section 02612 - Precast Reinforced Concrete Box Sewers.
- C. Provide pipe meeting minimum class, dimension ratio, or other criteria indicated.
- D. Pipe materials other than those listed above shall not be used for storm sewers.

2.03 BEDDING, BACKFILL, AND TOPSOIL MATERIAL

- A. Bedding and Backfill Material: Conform to requirements of Sections 02317 - Excavation and Backfill for Utilities, Section 02320 - Utility Backfill Materials, and Section 2321 - Cement Stabilized Sand, and Section 02322 - Flowable Fill.
- B. Topsoil: Conform to requirements of Section 02911 - Topsoil.

PART 3 EXECUTION

3.01 PREPARATION

- A. Prepare traffic control plans and set up street detours and barricades in preparation for excavation when construction will affect traffic. Conform to requirements of Section 01555 - Traffic Control and Regulation.

- B. Provide barricades, flashing warning lights, and signs for excavations. Conform to requirements of Section 01555 - Traffic Control and Regulation. Maintain barricades and warning lights for streets and intersections while Work is in progress or where traffic is affected by Work.
- C. Immediately notify agency or company owning utility lines which are damaged, broken, or disturbed. Obtain approval from Project Manager and agency for repairs or relocations, either temporary or permanent.
- D. Remove old pavements and structures, including sidewalks and driveways in accordance with requirements of Section 02221 - Removing Existing Pavements and Structures.
- E. Install and operate dewatering and surface water control measures in accordance with Section 01578 - Control of Ground and Surface Water.

3.02 EXCAVATION

- A. Earthwork. Conform to requirements of Section 02317 - Excavation and Backfill for Utilities. Use bedding as indicated on Drawings.
- B. Line and Grade. Establish required uniform line and grade trench from benchmarks identified by Project Manager. Maintain this control for minimum of 100 feet behind and ahead of pipe-laying operation. Use laser beam equipment to establish and maintain proper line and grade of Work. Or use appropriately sized grade boards which are substantially supported.
- C. Trench Excavation. Excavate pipe trenches to level as indicated on Standard Details. Backfill excavation with specified bedding material to level of lower one-third of pipe barrel. Tamp and compact backfill to provide bedding at indicated grade. Form bedding foundation to minimum depth of one-eighth of pipe diameter, but not less than 12-inches.

3.03 PIPE INSTALLATION

- A. Install in accordance with pipe manufacturer's recommendations and as specified in this section.
- B. Install pipe only after excavation is completed, bottom of trench is shaped, bedding material is installed, and trench has been approved by Project Manager.
- C. Install pipe to line and grade indicated on Drawings. Place pipe so that it has continuous bearing of barrel on bedding material with no voids, and is laid in trench so interior surfaces of pipe follows grades and alignments indicated.
- D. Install pipe with bells of pipe facing upstream of anticipated flow.
- E. Form concentric joint with each section of adjoining pipe to prevent offsets.
- F. Place and drive home newly laid sections with a sling or come-a-long winches to eliminate damage to sections. Unless otherwise approved by Project Manager, provide end protection

to prevent damage while using back hoes or similar powered equipment to drive home newly laid sections.

- G. Keep interior of pipe clean as installation progresses.
- H. Keep excavations free of water during construction and until final inspection.
- I. When work is not in progress, cover exposed ends of pipes with pipe plug specifically designed to prevent foreign material from entering pipe.
- J. For Flexible Pipe Products:
 - 1. Provide a minimum cover as per City Standard detail from top of pavement to top of pipe, but no less than 2 feet.
 - 2. Accomplish transitions to different material of pipe in a manhole or inlet box. No adapter, coupling for dissimilar pipe, or saddle connections allowed.
 - 3. Provide pipe sections in standard lengths with minimum length of 13 feet. Pipe may be field modified to shorten length no less than 4 feet, unless otherwise approved by Project Manager. Field modify pipe per manufacturer's recommendations.
 - 4. No beveling at joint allowed. Cut to be perpendicular to longitudinal axis.
 - 5. Provide gasketed bell and spigot joints installed per manufacturer's recommendations. Gasketed pipe joints; clean and free of debris, show no leakage after installation.

3.04 PIPE INSTALLATION OTHER THAN OPEN CUT OR TUNNELING

- A. Conform to requirements of Section 02448 - Pipe and Casing Augering for Sewers where required.
- B. Conform to requirements of Section 02441 - Microtunneling ~~and Pipe Jacked Tunnels~~ where required.
- C. Conform to requirements of Section 02445 – Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels where required.
- ED. Not allowed for plastic sewer pipe.

3.05 INSTALLATION OF APPURTENANCES

- A. Construct manholes to conform to requirements of Sections 02081 - Cast-in-place Concrete Manholes and Section 02082 - Precast Concrete Manholes. Install frames, grate rings, and covers to conform to requirements of Section 02090 - Frames, Grates, Rings, and Covers.
- B. Install PVC pipe culverts with approved end treatments. Approved end treatments include concrete headwalls, wingwalls and collars.

- C. Install HDPE and PP pipe culverts with approved end treatments. Approved end treatments include concrete headwalls, wingwalls and collars.
- D. Install inlets, headwalls, and wingwalls to conform to requirements of Section 02632 - Cast-in-place Inlets, Headwalls, and Wingwalls and Section 02633 - Precast Concrete Inlets, Headwalls, and Wingwalls.
- E. Rehabilitate existing manholes to conform to requirements of Section 02555 – Manhole Rehabilitation. Adjust manhole covers and inlets to grade conforming to requirements of Section 02086 - Adjusting Manholes, Inlets, and Valve Boxes to Grade.
- F. Dimension for Type C and Type E manholes shall be as shown on Drawings.

3.06 INSPECTION AND TESTING

- A. Perform post installation television inspection in accordance with Section 02531 – Gravity Sanitary Sewers. Hand held cameras may be used in storm sewers in lieu of requirements of Paragraph 3.09 of Section 02531 – Gravity Sanitary Sewers. Clearly stencil distance markings on each joint of pipe to indicate distance from starting manhole when using hand held cameras.
- B. MANDREL TESTING: use a mandrel to test flexible pipe for deflection. Refer to Section 02533 – Acceptance Testing for Sanitary Sewers for the mandrel and test requirements.

3.07 BACKFILL AND SITE CLEANUP

- A. Backfill trench after pipe installation is inspected and approved by Project Manager.
- B. Backfill and compact soil in accordance with Section 02317 - Excavation and Backfill for Utilities.
- C. Repair and replace removed or damaged pavement and sidewalks as specified in Section 02951 - Pavement Repair and Restoration.
- D. In unpaved areas, grade surface as uniform slope to natural grade as indicated on Drawings. Provide minimum of 4 inches of topsoil and seed according to requirements of Section 02921 Hydro Mulch Seeding, or Section 02922 - Sodding, as required.

END OF SECTION