SECTION 02255
STEEL PIPE AND FITTINGS FOR LARGE DIAMETER WATER LINES

PART I: GENERAL

1.1 GENERAL REQUIREMENTS
- A. Large diameter [twenty-four inches (24 In) and greater] steel pipe and fittings for water lines and pumping facilities.

1.2 MEASUREMENT AND PAYMENT
- A. Unit Prices:
  1. No separate payment will be made for steel pipe and fittings under this Section. Include cost in the unit price for water lines, pumping facilities and encasement sleeves.
  2. Refer to Section 01270 – Measurement and Payment for unit price procedures.
- B. Stipulated Price (Lump Sum):
  1. If Contract is Stipulated Price Contract, payment for work in this Section is included in Total Stipulated Price.

1.3 REFERENCES
- A. AASHTO – American Association of State Highway and Transportation Officials.
  1. AASHTO – Standard Specifications for Highway Bridges.
- B. AREMA – American Railway Engineering and Maintenance-of-way Association.
  1. AREMA – Manual for Railway Engineering, Volume II, Chapter 15.
- C. ASTM – American Society for Testing and Materials.
  1. ASTM A36 – Standard Specification for Structural Steel.
  2. ASTM A53 – Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
  3. ASTM A135 – Standard Specification for Electric-Resistance-Welded Steel Pipe.
  4. ASTM A139 – Standard Specification for Electric-Fusion (ARC) – Welded Steel Pipe (NPS 4 and Over).
  5. ASTM A570 – Standard Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality.
  6. ASTM C33 – Standard Specification for Concrete Aggregates.
  7. ASTM C35 – Standard Specification for Inorganic Aggregates for Use in Gypsum Plaster.
  8. ASTM C150 – Standard Specification for Portland Cement.
  9. ASTM C494 – Standard Specification for Chemical Admixtures for Concrete.
  10. ASTM C595 – Standard Specification for Blended Hydraulic

Cements.

11. ASTM C881 – Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
12. ASTM C1107 – Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).
13. ASTM D512 – Standard Test Methods for Chloride Ion in Water.
14. ASTM D1293 – Standard Test Methods for pH of Water.
15. ASTM D3363 – Standard Test Method for Film Hardness by Pencil Test.
16. ASTM D4541 – Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Tests.
17. ASTM D4752 – Standard Test Method for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub.

D. AWWA – American Water Works Association.
   1. AWWA C200 – Steel Water Pipe 6 in. and Larger.
   2. AWWA C205 – Cement-Mortar Protective Lining and Coating for Steel Water Pipe.
   3. AWWA C206 – Standard for Field Welding of Steel Water Pipe.
   4. AWWA C207 – Standard for Steel Pipe Flanges for Waterworks Service – Sizes 4 in. through 144 in.
   5. AWWA C208 – Dimensions for Fabricated Steel Water Pipe Fittings; Addendum C 208A.
   6. AWWA C209 – Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections and Fittings for Steel Water Pipelines.
   7. AWWA C210 – Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
   8. AWWA C214 – Tape Coating Systems for the Exterior of Steel Water Pipelines.
   9. AWWA C602 – Cement-Mortar Lining of Water Pipelines – 4 In. (100 mm) and Larger – In Place.
   10. AWWA M11 – Steel Pipe-A Guide for Design and Installation.

E. CFTS – City of Friendswood Technical Specifications.

F. SSPC – Steel Structures Painting Council.
   1. SSPC Good Painting Practice, Volume 1.
   2. SSPC SP1 – Surface Preparation Specification No. 1 Solvent Cleaning.
   3. SSPC SP5 – Joint Surface Preparation Standard White Blast Cleaning.
   4. SSPC SP6 – Surface Preparation Specification No. 6 Commercial Blast Cleaning.
   5. SSPC SP10 – Surface Preparation Specification No. 10 Near-White Blast Cleaning.
   6. SSPC VIS1 – Visual Standard for Abrasive Blast Cleaned Steel.

1.4 SUBMITTALS

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

B. Submit shop drawings signed and sealed by a Professional Engineer licensed by the State of Texas showing following:

1. Manufacturer's pipe design calculations.
2. Provide lay schedule of pictorial nature indicating alignment and grade, laying dimensions, welding procedures, fabrication, fitting, flange and special details, with plan view of each pipe segment sketched, detailing pipe invert elevations, horizontal bends, welded joints and other critical features. Indicate station numbers for pipe and fittings corresponding to the Drawings. Do not start production of pipe and fittings prior to review and approval by the Project Manager. Provide final approved lay schedule on CD-ROM in Adobe portable document format (*.PDF).
3. Include hot tapping procedure.
4. Submit certification from manufacturer that design was performed for project in accordance with requirements of this Section. Certification to be signed and sealed by a Professional Engineer licensed by the State of Texas.

C. Submit manufacturer's certifications that pipe and fittings have been hydrostatically tested at factory in accordance with AWWA C200, Section 3.4.

D. Submit certification from NACE Certified Coatings Inspector, under supervision of inspector having Level III certification for coatings and linings, that steel pipe furnished on project was properly inspected and defective coatings detected properly repaired.

E. Submit inspection procedures to be used by manufacturer and for quality control and assurance for materials and welding. Submit at least thirty days (30 D) prior to repair work, procedures that describe in details shop and field work to be preformed. Repair defects such as substandard welds, excessive radial offsets (misalignment), pitting, gouges, cracks, etc.

F. Submit following for nonshrink grout for special applications:

1. Manufacturer's technical literature including the Technical Specifications for mixing, placing and curing grout.
2. Results of tests performed by certified independent testing laboratory showing conformance to ASTM C1107, Nonshrink Grout and requirements of this specification.
3. Certification product is suitable for use in contact with potable water.

G. Submit proof of certification for welders. Indicate certified procedures and position each welder is qualified to perform. Ensure welder and welding operator have been certified within past six months (6 Mos) in accordance with AWWA C206.

H. Within forty-five calendar days (45 cD) after manufacturing of all pipe,

submit affidavit of compliance that materials and work furnished comply with applicable requirements of referenced standards and these Technical Specifications. Make available copy of physical and chemical testing reports.

I. Within forty-five days (45 D) of manufacturing of all pipe, submit manufacturer's affidavits that coatings and linings comply with applicable requirements of this Section and:
   1. Polyurethane coatings were applied in accordance with manufacturer's recommendation and allowed to cure at temperature five degrees Fahrenheit (5° F) above dew point.
   2. Mortar coatings and linings were applied and allowed to cure at temperature above thirty-two degrees Fahrenheit (32° F).
   3. Test Results:
      a. Compressive strength [seven day (7 D) and twenty-eight day (28 D)] test results for mortar coating.
      b. Hydrostatic testing, magnetic particle and x-ray weld test reports as required.

J. Prior to start of field-applied cement mortar lining operation, submit comprehensive plan which identifies and describes as minimum:
   1. Equipment used for batching, weighing, mixing transporting and placing mortar.
   2. Qualifications and specific experience of machine operators.
   3. Source and type of cement, pozzolan, sand and admixtures used and certifications from suppliers that materials meet the Technical Specifications.
   4. Mix proportions to be used and slump limits (max. and min.).
   5. A quality control plan which identifies quality control material tests and documented inspections necessary to ensure compliance with specified requirements.

K. Submit certification showing calibration within last twelve months (12 Mos) for equipment such as scales, measuring devices and calibration tools used in manufacture of pipe. Each device used in manufacture of pipe is required to have tag recording date of last calibration. Devices are subject to inspection by the Project Manager.

1.5 QUALITY CONTROL

A. Manufacturer to provide permanent quality control department and laboratory facility capable of performing inspections and testing as required by the Technical Specifications. Material testing, inspection procedures and manufacturing process are subject to inspection by the Project Manager. Perform manufacturer's tests and inspections required by referenced standards and these Technical Specifications, including the following. Correct nonconforming conditions.
   1. Steel Plate and Coils: Review mill certifications for conformance to requirements of the Technical Specifications; perform physical and chemical testing of each heat of steel for conformance to

applicable ASTM standards.

2. Pipe:
   a. Inspect thickness, circumference, roundness, strength and size of seam welds (spiral or longitudinal) and squareness of pipe ends to verify compliance with AWWA C200.
   b. Inspect physical dimensions and overall conditions of all joints for compliance with AWWA C200, approved submittals and Technical Specifications.
   c. Hydrostatically test finished pipe section to seventy-five percent (75%) of specified minimum yield strength of steel being used with zero (0) leakage.
   d. For wall thickness greater than one-half inch (1/2 In) perform Charpy V-Notch (CVN) Test in accordance with AWWA C200.
3. Linings:
   a. Inspect unlined pipe for overall condition of inside barrel. Maintain inside barrel free of corrosive products, oil, grease, dirt, chemical and deleterious material.
   b. Inspect lined pipe for physical dimensions and overall condition of lining, visible surface defects, thickness of lining and adhesion to steel surface.
   c. Review certifications by manufacturers of lining components for conformance to AWWA standards and these Technical Specifications.
4. Coatings: Measure temperature and dew point of ambient air before applying coatings. Inspect physical dimensions and overall condition of coatings. Inspect for visible surface defects, thickness and adhesion of coating to surface and between layers.
5. Final Inspection:
   a. Before shipment, inspect finished pipe, fittings, specials and accessories for markings, metal, coating thickness, lining thickness (if shop applied), joint dimensions and roundness.
   b. Inspect for coating placement and defects. Test exterior coating for holidays.
   c. Inspect linings for thickness, pitting, scarring and adhesion.

B. Shop-applied coatings and linings; provide services of independent coating and lining inspection service or testing laboratory with qualified coating inspectors. Perform inspection by National Association of Corrosion Engineers (NACE) trained inspectors under supervision of NACE Level III Certified Coatings Inspector.

C. Ensure workmen engaged in manufacturing are qualified and experienced in performance of their specific duties.

D. Cast four (4) standard test cylinders each day for each fifty cubic yards (50 Cy) of mortar coating or portion thereof for each coating and lining placed in a day. Perform compressive strength test at twenty-eight days (28 D). No cylinder test result shall be less than eighty percent (80%) of specified strength.
E. Dented steel cylinders shall result in rejection of pipe.
F. Make available copy of physical and chemical testing reports for steel cylinders and provide reports at request of the Project Manager.
G. Check physical dimensions of pipe and fittings. Physical dimensions to include at least pipe lengths, pipe I.D., pipe O.D. and bend angles.

1.6 INSPECTION

A. The Project Manager may witness manufacture and fabrication of pipe and appurtenances. Independent testing laboratory under contract to the Project Manager may perform tests at direction of the Project Manager to verify compliance with these Technical Specifications. Provide assistance to accomplish such testing, including equipment and personnel, at no additional cost to the City.

PART II: PRODUCTS

2.1 STEEL PIPE

A. Furnish pipe by same manufacturer.
B. Furnish pipe smaller than twenty-four inch (24 In) in accordance with Section 02250 – Steel Pipe and Fittings.
C. Fabricate and supply miscellaneous steel pipe and fittings with nominal diameter of twenty-four inches (24 In) and larger in accordance with AWWA C200, C207, C208 and AWWA M11 except as modified herein. Steel to be a minimum of ASTM A36, ASTM A570 Grade 36, ASTM A53 Grade B, ASTM A135 Grade B or ASTM A139 Grade B.
D. Provide pipe sections in lengths no greater than forty feet (40 Ft) and no less than ten feet (10 Ft) except as required for special fittings or closure sections.
E. Provide shop-coated and shop-lined steel pipe with minimum of one (1) coat of shop-applied primer approved for use in potable water transmission on all exposed steel surfaces. Primer for tape-coated steel pipe to be used for field-applied coatings shall have no less than five percent (5%) solids. Provide primer compatible with coating system and in accordance with coating manufacturer's recommendations.
F. Provide closure sections and short sections of steel pipe not less than four feet (4 Ft) in length unless indicated on the Drawings or specifically permitted by the Project Manager.
G. Square flanges with pipe with bolt holes straddling both horizontal and vertical axis. Provide one-half inch (1/2 In) gap between pipe ends to be coupled with sleeve coupling unless otherwise indicated on the Drawings.

1. Provide standard ring or hub type flanges, conforming to AWWA C207, Class D.
2. Apply Densco petroleum-based tape or approved equal to exposed portions of nuts and bolts.

H. Pipe Design Conditions:

1. Design: Design pipe and fittings to withstand most critical simultaneous application of external loads and internal pressures. Base design on minimum of AASHTO HS-20 loading, AREMA E-80 loads and depths of bury as indicated on the Drawings. Design pipes with Marston's earth loads for transition width trench for all heights of cover.
2. Groundwater Level: Design for most critical ground water level condition.
3. Working pressure = One hundred pounds per square inch (100 psi).
4. Hydrostatic field test pressure = One hundred fifty pounds per square inch (150 psi).
5. Maximum pressure due to surge = One hundred fifty pounds per square inch (150 psi).
6. Minimum pressure due to surge = Minus five pounds per square inch (-5 psi).
7. Modulus of elasticity (E) = Thirty million pounds per square inch (30000000 psi).
8. Maximum deflection from specified diameter: Two percent (2%) for mortar coating; three percent (3%) for flexible coatings and three percent (3%) for mortar lining.
9. Design stress due to working pressure to be no greater than fifty percent (50%) of minimum yield and stress not to exceed sixteen thousand five hundred pounds per square inch (16500 psi) for mortar coated pipe.
10. Design stress due to maximum hydraulic surge pressure to be no greater than seventy-five percent (75%) of minimum yield and stress not to exceed twenty-four thousand seven hundred fifty pounds per square inch (24750 psi) for mortar coated pipe.
11. Modulus of soil reaction (EN) < one thousand five hundred pounds per square inch (1500 psi). If EN > one thousand pounds per square inch (1000 psi), do not use silty sand (SM) for embedment.
12. Unit weight of fill (w) > One hundred twenty pounds per cubic foot (120 pcf).
13. Deflection lag factor (D1) = One and two tenths (1.2).
14. Bedding constant (K) = One tenth (0.1).
15. Fully saturated soil conditions: hw = h = depth of cover above top of pipe.
16. Do not allow diameter (D) over thickness (t) ratio to be greater than two hundred thirty (230).

17. Nominal Allowable Steel-wall Thickness for Water Lines: Provide in accordance with following table for HS-20 live loads and depths of cover of up to sixteen feet (16 Ft). Net internal diameter (including inside linings) to be no less than net inside diameter listed. The Contractor to review design for conditions more extreme than those indicated by this specification and design accordingly. If, in opinion of the Project Manager, proposed pipe wall thicknesses appear inadequate for indicated loading conditions, submittal of design calculations shall be required for review. Pipe wall to be not less than that specified in TABLE 4.1 PIPE WALL THICKNESSES in this Section.

I. Fittings for Water Lines: Fabricate in accordance with AWWA M11, Section 13.3-13.7 and AWWA C208.
   1. Wall Thickness: Equal to or greater than pipe to which fitting is to be welded.
   2. Elbows: two (2) pieces for zero degrees (0°) to twenty-two and one-half degrees (22-1/2°); three (3) pieces for twenty-three degrees (23°) to forty-five degrees (45°); four (4) pieces for forty-six degrees (46°) to sixty seven and one-half degrees (67-1/2°); and five (5) pieces for sixty-eight degrees (68°) to ninety degrees (90°), unless otherwise shown on the Drawings.
   3. Outlets: Reinforced in accordance with AWWA M11, Sections 13.3-13.7, AWWA C200 and AWWA C208. Provide interior lining and exterior coating in accordance with paragraphs on coating and lining and matching pipe to access inlets, service outlets, test inlets and air-vacuum valve and other outlets, including riser pipes.
   4. Radius: Minimum radius of two and one-half (2-1/2) times pipe diameter.
   5. Butt Straps for Closure Piece: Minimum twelve inch (12 In) wide split butt strap; minimum plate thickness equal to thinnest member being joined; fabricated from material equal in chemical and physical properties to thinnest member being joined. Provide minimum lap of four inches (4 In) between member being joined and edge of butt strap, welded on both inside and outside, unless otherwise approved by the Project Manager. Provide minimum six inch (6 In) welded outlet for inspecting each closure section, unless access manway is within forty feet (40 Ft) of closure section.
   6. Joints are to be double-welded and butt or lap joints as shown on the Drawings. Use flanged joints at valves.
   7. Provide double-welded lap field joints or full penetration butt-welded joints for tee fitting supported on pier foundation, aboveground piping and field welds for risers including vertical portion of crossover piping.

J. Joints:

1. Standard field joint for steel pipe: AWWA C206. Rubber gasket Carnegie shape joint or rolled-groove rubber gasket and O-ring joint, sixty-six inch (66 In) maximum diameter. Joints may be lap-welded slip type in accordance with AWWA C206, except where flanged joints or butt strap joints are required.
2. Provide double-welded butt joints at aerial crossings and where noted on the Drawings.
3. Pipe Manufacturer: Minimum of five years (5 Yrs) of successful service with proposed field joint or submit results from joint tests determined by the Project Manager. Tests which may be required include tensile strength or yield tests of base material and spiral welded sections (API 5L), flattening tests, chemical analysis, impact and hardness tests. The Project Manager's decision as to acceptability of joint is final.
4. Capable of withstanding jacking forces.
5. Design restrained joints for test pressure or maximum surge pressure as specified, whichever is greater. Only minimum restrained joint lengths for prestressed concrete cylinder pipe are shown on the Drawings.
6. Provide full circumferential welds at joints required to be welded.
7. Use wire and flux from same manufacturer throughout entire project.
8. Rubber Gasketed Bell-and-Spigot Joints.
    a. Bells: Formed by either expansion of pipe end or by segmental expander which stretches steel past its elastic limit or by attaching sized weld-on bell rings. Spigot ends: Sized prior to rolling gasket groove. Joints: Interchangeable and match up during installation, even if used out of sequence. Weld-on bell rings: AWWA M11; AWWA C200; attached with single or double, full thickness fillet welds (double weld in areas of thrust restraint).
    b. Provide bells and spigots with dimensions and tolerances in accordance with AWWA C200, as modified herein. Difference in diameter between I.D. of bell and O.D. of spigot shoulder at point of full engagement with allowable deflection range of zero inch (0.00 In) to four hundredths inch (0.04 In) as measured on circumference with diameter tape. Minimum thickness of completed bell ring is equal to thickness of pipe wall in barrel of pipe between joint ends.
    c. Furnish joint suitable for safe working pressure equal to class of pipe and shall operate satisfactorily with deflection, tangent of which is not to exceed seventy-five hundredths inch per inch diameter (0.75 In/D) where D is outside diameter of pipe in inches or with pull-out of

three-quarters inch (3/4 In).

d. Design clearance between bells and gasketed spigots so, when joint is assembled, it shall be self-centered and gasket shall be restrained or confined to annular space in such manner that movement of pipe or hydrostatic pressure cannot displace it. Compression of gasket when joint is completed shall not be dependent upon water pressure in pipe and shall provide watertight joints under operating conditions when properly installed.

K. Manufacturer must maintain on site or in plant enough fittings as specified in TABLE 4.2 – REQUIRED BENDS STOCK in this Section.

L. Manufacturer must be capable of delivering bends to job site within twelve hours (12 Hrs) of notification. Use fittings at direction of the Project Manager where unforeseen obstacles are encountered during construction. These fittings are in addition to fittings called out on the Drawings and must be available at all times. Use same product throughout entire project.

M. Perform x-ray or ultrasonic testing of manual welds on special pipe and fittings.

N. Hydrostatic Test of Pipe:
   1. AWWA C200, Section 3.5.3, at point of manufacture. Hold test for minimum two minutes (2 Min) and conduct thorough inspection of pipe. Repair or reject pipe revealing leaks or cracks.
   2. Calibrate pressure gauges within one year (1 Yr) prior to testing as specified in Section 1.4.L.

O. Provide forged steel threaded outlets of approved design where required for use in passing hose or lead wires into pipe. Tap plugs with standard pipe threads and weld to pipe in approved manner and use solid forged steel plugs for closure.

P. Flanges:
   1. Fabricate flanges with oversize bolt holes, with flanges drilled in pairs, to accommodate insulating sleeves.
   2. Test, coat, line and ship each shop-assembled insulated flange assembly to field as fitting. Use no less than two (2) snug-fitting alignment pins to assist in aligning flanges during assembly. Do not remove pins until bolts have been installed in all remaining holes and have been drawn up tight. After insulating joints have been assembled, subject each assembly (fitting) to shop hydrostatic test pressure of one hundred fifty pounds per square inch (150 psi) and electrically test to ensure that insulated sections are effective. After assembly has been tested, coat insulating joint and adjacent steel pipe as specified for below-ground installation. Line assembly as specified for interior surfaces and in accordance with details shown on the Drawings.

Q. Dished Head Plugs: Design dished head plugs (test plugs) to withstand

field hydrostatic test pressure from either side of plug. Design stress due to hydrostatic pressure to be no greater than fifty percent (50%) of minimum yield. Pipe on opposite side of hydrostatic test may or may not contain water. Manufacturer of the steel pipe to hydrostatically test plug at factory.

R. Make curves and bends by deflecting joints or by using beveled joints or by combination of two (2) methods, unless otherwise indicated on the Drawings or permitted by the Project Manager. Do not exceed deflection angle at joint as recommended by pipe manufacturer. Make penetration of spigot into bell at all points of circumference at least equal to minimum required penetration shown on the Drawings. Beveled pipe sections used in curved alignment to be of standard length except when shorter sections are required to limit radius of curvature, in which case all sections throughout curve are to be of equal length. Do not allow bevel to exceed five degrees (5°).

2.2 INTERNAL LINING SYSTEMS FOR STEEL PIPE, ALL INSTALLATIONS

A. Supply steel pipe with either epoxy lining or cement-mortar lining, capable of conveying water at temperatures not greater than one hundred forty degrees Fahrenheit (140° F). Provide linings conforming to American National Standards Institute/National Sanitation Foundation (ANSI/NFS) Standard 61 and certification to be from organization accredited by ANSI. Unless otherwise noted, coat all exposed (wetted) steel parts of flanges, blind flanges, bolts, access manhole covers, with epoxy lining, as specified.

B. Epoxy Lining:

1. AWWA C210, color White or approved equal for shop and field joint applied, except as modified in this Section. Provide materials from same manufacturer. Protect interior surface with approved liquid two (2) part chemically cured epoxy primer for interior surfaces as specified in TABLE 4.3 – EPOXY PRIMER FOR INTERIOR SURFACES in this Section.
2. Total allowable dry film thickness for system:
   a. Minimum: Twelve (12) mils.
   b. Maximum: Eighteen (18) mils.
3. Provide dry film thicknesses for approved alternate products in accordance with product's manufacturer recommendations.
4. Lining system may consist of three (3) or more coats of same approved alternate epoxy lining without use of separate primer.
5. Perform adhesion test on pipe forty-eight inches (48 In) in diameter and larger in accordance with ASTM D4541. Minimum field adhesion: seven hundred pounds per square inch (700 psi). Perform test on pipe for project at frequency of one (1) for every one thousand square feet (1000 Sf) of epoxy lining. Perform cure test in accordance with ASTM D4752 (solvent rub test) and ASTM D3363 (pencil hardness) for each section of pipe. Repair

tested areas with approved procedures.

C. Shop-applied Cement-mortar Lining:
   1. AWWA C205; except as specified herein: one-half inch (1/2 In) minimum thickness for pipe diameters forty-two inches (42 In) and larger; three-eighths (3/8) inch minimum thickness for pipe diameters thirty-six inches (36 In) and smaller. Cut back lining from joint ends no more than two inches (2 In) to facilitate joining and welding of pipe.
   2. Apply cement-mortar lining to inside of pipe by centrifugally spinning. For special sections (shape of which precludes application by spinning method) accomplish by mechanical placement or pneumatic placement and finish to produce smooth, dense surface comparable to centrifugally spinning.
   3. Use galvanized wire mesh when shop-applied mortar is not applied by machine. Do not extend wire mesh across welded portion of mitered fittings. Crimp mesh to provide integral "chair" so wire does not fully rest against steel cylinder.
   4. Make repairs of cement-mortar lining for widths exceeding six inches (6 In) by bonding to steel and adjacent faces of lining with bonding agent conforming to ASTM C881, Type II.
   5. Restrict usage of sprinkler heads during moist curing to prevent over spraying onto lining. No alternative curing methods are allowed as described in Section 4.4.7.4 of AWWA C205.
   6. Satisfy the Project Manager that above requirements can be accomplished by manufacturer prior to shipment of pipe.

D. Field-applied Cement-mortar Lining (for pipe > forty-eight inches (48 In) in diameter): Provide field-applied internal cement-mortar linings in accordance with AWWA C602, latest edition, except as modified in this Section.
   1. Lining: Applied in one (1) course application of cement-mortar by machine that centrifugally places mortar against wall of pipe and mechanically trowel lining to smooth finish.
   2. Steel pipe, fittings, receives cement-mortar lining.
   3. Cement-mortar for lining.
      a. Cement-mortar: Dense, smooth and of uniform quality and consistency to assure efficient machine operation and uniform cement-mortar lining on pipe wall.
      b. Water-cement ratio: Kept as low as possible; consistent with proper plasticity for application, allowing slight variations dependent upon temperature, length of haul for mortar and moisture condition in pipe.
      c. Mortar: Mixture of one (1) part cement with not less than one (1) or more than one and one-half (1-1/2) parts of dry screened sand, by volume. After determining mixture, control materials to within plus or minus two and one-half percent (2-1/2%) by weight throughout entire

work.

d. Comply with following materials for cement-mortar:
   1) Provide Type II low-alkali Portland cement conforming to ASTM C150 or Type IP (MS) Portland-Pozzolan cement conforming to ASTM C595, unless otherwise specified. Conform to low alkali requirements of Table IA of ASTM C150. Type IP (MS) cement to contain no more than percent (20%) Pozzolan, to be inter-ground with clinker.
   2) Use suitable facilities approved by the Project Manager when available for handling and weighing bulk cement. Otherwise, deliver cement in original unopened sacks that have been filled by manufacturer. Plainly mark sacks with manufacturer's name or brand, cement type lot number and weight. Discard unused cement. Use unopened bags of cement for each new batch.
   3) Material storage: Store cement to permit ready access for inspection and sampling. Protect cement and sand against contamination or moisture. Do not use and remove from site cement delivered with evidence of contamination or otherwise unsuitable. Store admixtures in accordance with manufacturer's directions.
   4) Use Portland cement of same brand and type unless otherwise approved by the Project Manager.
   5) Pozzolanic material: AWWA C602, Paragraph 2.2.
   6) Sand: AWWA C205, Section 2.3, except gradation of sand to yield fineness modulus of approximately 1.7; having no material coarser than that passing No. 16 sieve. Submit certification for compliance of sand with these Technical Specifications at least ten calendar days (10 cD) before start of lining placement.
   7) Water: Clean; free of deleterious amounts of acids, alkalis or organic materials; total dissolved solids less than one thousand milligrams per liter (1000 mg/l); ASTM D512 chloride ions less than one hundred milligrams per liter (100 mg/l) for slurry and mortar cure; ASTM D1293 pH greater than 6.5.

2.3 EXTERNAL COATING SYSTEM FOR STEEL PIPE INSTALLED ABOVEGROUND AND IN VAULTS (EXPOSED)

A. Provide approved three (3) coat epoxy/polyurethane coating system as specified in TABLE 4.4 – THREE COAT EPOXY/POLYURETHANE COATINGS in this Section. Provide materials from same manufacturer.
B. Total Allowable Dry Film Thickness for System:
   1. Minimum: Nine and one-half (9.5) mils.
   2. Maximum: Twelve and one-half (12.5) mils.
C. Perform adhesion test on pipe forty-eight inches (48 In) in diameter and larger in accordance with ASTM D4541. Minimum field adhesion: seven hundred pounds per square inch (700 psi). Perform test on pipe for project at frequency of one (1) for every 1000 square feet of epoxy lining. Perform cure test in accordance with ASTM D4752 (solvent rub test) and ASTM D3363 (pencil hardness) for each section of pipe. Repair tested areas with approved procedures.

2.4 EXTERNAL COATING SYSTEMS FOR BURIED STEEL PIPE
A. Supply pipe with one (1) of the following coatings specified.
   1. Tape Coating: Provide approved tape for external tape coating. Apply in accordance with AWWA C214 and requirements of this section; eighty (80) mil.
      a. Components: Primer, one (1) twenty (20) mil layer of inner-layer tape for corrosion protection and two (2) thirty (30) mil layers of outer-layer tape for mechanical protection.
      b. Where sleeve type or victaulic couplings are required, bond coupling to adjacent pipes with bonding cables as shown on the Drawings.
      c. Use approved filler putty type insulating putty to fill in gap and create smooth sloped transition between top of reinforcing plate and pipe, before tape coating is applied.
      d. Primer: Compatible with tape coating, supplied by coating-system manufacturer.
      e. Provide pipe with shop coatings cut back approximately four inches (4 In) to four and one-half inches (4-1/2%) from joint ends to facilitate joining and welding of pipe. Taper successive tape layers by one inch (1 In) staggers to facilitate field wrapping and welding of joints.
      f. Inner and outer tape width: Twelve inches (12 In) or eighteen inches (18 In).
      g. Do not expose tape coating to direct sunlight for more than sixty days (60 D).
   2. Cement-mortar Coating: AWWA C205; shop-applied, cement-mortar coating except as modified in this Section; one inch (1 In) minimum thickness; cut back coating from joint ends no more than two inches (2 In) to facilitate joining and welding of pipe.
   3. Polyurethane Coating: See Section 02265 – Polyurethane Coatings on Steel or Ductile Iron Pipe for requirements for use

of polyurethane coating system.

B. Heat Shrink Joint Sleeves for Tape and Polyethane Coating: Aqua-shield or approved equal. For repairs to heat shrink joint sleeves, use Aqua-shield Repair Patch Kit or approved equal.

2.5 GROUT FOR JOINTS AND SPECIAL APPLICATIONS

A. Cement Grout Mixture: One (1) part cement to two (2) parts of fine, sharp clean sand. Mix interior joint mortar with as little water as possible until very stiff but workable. Mix exterior joint mortar with water until it has consistency of thick cream. Mix cement grout to specific gravity of nineteen pounds per gallon (19 Lb/Gal) or greater as measured by grout/slurry balance. Use balance manufactured grout/slurry by Baroid or approved equal. Perform test in presence of and at request of the Project Manager. Add additional cement grout or water to mixed cement grout to bring mix to proper moisture content or specific gravity. Discard cement grout that has been mixed more than twenty minutes (20 Min) and is not at proper specific gravity or moisture content.

1. Portland Cement: ASTM C150, Type II. Provide one (1) type of cement for entire project.
2. Sand:
   a. Interior joints: ASTM C35 fine graded plaster sand.
   b. Exterior joints: ASTM C33; natural sand with one hundred percent (100%) passing No. 16 sieve.
3. Water: Potable water with total dissolved solids less than one thousand milligrams per liter (1000 mg/l); ASTM D512 chloride ions less than one hundred milligrams per liter (100 mg/l) for slurry and mortar cure; ASTM D1293 pH greater than 6.5. Use potable water with two hundred fifty parts per million (250 ppm) limit on chlorides and sulfates.

B. Provide approved Nonshrink Grout for Special Applications, Patches and Repairs.

1. Conform to requirements of ASTM C1107, Nonshrink Grout.
2. Pre-blended factory-packaged material manufactured under rigid quality control, suitable for use in joints of prestressed concrete cylinder pipe.
3. Contain non-metallic natural aggregate and be nonstaining and noncorrosive.
4. Meeting NSF 61 Standard suitable for use in contact with potable water supply.
5. Exterior: Highly flowable to fill joint wrapper without leaving voids or trapped air. Interior capable of being placed with plastic consistency.
6. Compressive strength: ASTM C1107 two thousand five hundred pounds per square inch (2500 psi) minimum seven day (7 D) unconfined; five thousand pounds per square inch (5000 psi) minimum twenty-eight day (28 D) unconfined.

7. Non-bleeding and non-segregating at fluid consistency.
8. Contain no chlorides or additives which may contribute to corrosion of steel pipe.
9. Free of gas-producing, gas-releasing agents.
10. Resist attack by oil or water.
11. Mix, place and cure in accordance with manufacturer's instructions and recommendations. Upon seventy-two hours (72 Hrs) notice, provide services of qualified representative of nonshrink grout manufacturer to aid in assuring proper use of product under job conditions. Representative to be on site when product is first (1st) used.
12. Mix cement grout to specific gravity of seventeen and seven-tenths pounds per gallon (17.7 Lb/Gal) or greater as measured by grout/slurry balance. Use balance manufactured grout/slurry by Baroid or approved equal. Perform test in presence of and at request of the Project Manager. Add additional cement grout to mixed cement grout or water to bring mix to proper moisture content or specific gravity. Discard cement grout that has been mixed more than twenty minutes (20 Min) and is not at proper specific gravity or moisture content.
13. Compressive strength: ASTM C1107 two thousand five hundred pounds per square inch (2500 psi) minimum seven day (7 D) unconfined; five thousand pound per square inch (5000 psi) minimum twenty-eight day (28 D) unconfined.

C. Finished surface of lining and interior joint to be comparable to surface rubbed with No. 16 Carborundum stone. Rub joint mortar sufficiently to bring paste to surface, to remove depressions and projections and to produce smooth, dense surface. Add cement to form surface paste as necessary. Leave interior with clean, neat and uniform-appearing finish.

D. Joint Wrapper: Minimum width of nine inches (9 In) for thirty-three inch (33 In) diameter and smaller; minimum width of twelve inches (12 In) for diameters greater than thirty-three inch (33 In) hemmed at edge to allow threading with minimum five-eighths inch (5/8 In) wide steel strap. Provide minimum six inch (6 In) wide Ethafoam strip sized, positioned and sewn such that two (2) circumferential edges of Ethafoam are one and one-half inches (1-1/2 In) from outer edge of wrapper.

2.6 COLD-APPLIED TAPE COATING

A. Shop-applied Tape Wrap Coating

1. Use primer furnished by tape manufacturer.
2. Wrap, specials and fittings that cannot be machine wrapped due to configuration with primer layer and two (2) layers of prefabricated tape each thirty-five (35) mils thick.
3. Overlap machine applied tape with hand applied tape by minimum of two inches (2 In) and bind to it.
4. Apply approved thirty (30) mil filler tape parallel to spiral weld

seams if weld height measures greater than or equal to one-eighth inch (1/8 In).

B. Surface Preparation
   1. Clean bare pipe from mud, mill lacquer, oil, grease or other contaminants. Inspect and clean surfaces according to SSPC SP1 to remove oil, grease and loosely adhering deposits prior to blast cleaning. Remove visible oil and grease spots by solvent wiping. Use approved safety solvents which do not leave residue. Preheating to remove oil, grease, mill scale, water and ice may be used provided pipe is preheated in uniform manner to avoid distortion.
   2. Remove surface imperfections such as slivers, scabs, burrs, weld spatter and gouges by hand filling or grinding to prevent excessive number of holidays. Presence of metallic defects may be cause for rejection of pipe.

2.7 EXTERNAL TAPE COATING SHOP APPLICATION
   A. Separate tape dispensing equipment far enough apart to visually inspect continuous steps.
   B. Make cutbacks straight and for total thickness of coating.
   C. State of dryness of primer prior to application of weld filler and inner layer of tape to be in accordance with written recommendation of manufacturer.
   D. Apply weld filler tape over primer and extend minimum of one inch (1 In) on each side of weld seam. Filler tape may contact rollers as long as release liner is in place and adhesion requirements are met. Remove release liner before applying inner layer tape.
   E. Spirally apply inner layer of tape in direction of helix weld. Overlap each spiral of tape one inch (1 In) or greater with next successive spiral of tape applied.
   F. Overlap end of new roll on top of previous roll minimum of six inches (6 In).
   G. Tape-roll body temperature to be greater than seventy degrees Fahrenheit (70° F); pipe surface temperature to be greater than sixty degrees Fahrenheit (60° F).
   H. Spirally apply outer layer tapes in direction of helix weld and use overlap width and application tensions as recommended by manufacturer.

2.8 INSPECTION AND TESTING OF COATINGS
   A. Perform electrical inspection on inner layer of tape before intermediate layer of tape is applied.
   B. If holidays are detected, repair holidays immediately before applying outer layer of tape. Clear holiday area of material and reprime if necessary. Recoat area with inner wrap tape. Overlap inner wrap tape onto surrounding inner wrap coating by at least two inches (2 In). Perform electrical retest at repaired area after repairing holiday and before outer wrap is continued.

C. Shrink Wrap: Perform electrical inspection on shrink wrap to check for holidays. Perform peel tests over heat affected zone. Minimum acceptable result: fifteen foot-pounds per inch (15 Ft-Lbs/In).

PART III: EXECUTION

3.1 PIPING INSTALLATION

A. Conform to applicable provisions of Section 02400 – Water Lines, except as modified in this Section.

B. Comply with following:

1. Make available services of manufacturer's representative when deemed necessary by the Project Manager. Representative to advise in aspects of installation, including but not limited to handling and storing, cleaning and inspecting, coating and lining repair and general construction methods as applicable to pipe.
2. Install stulls prior to placement of pipe, bends and fittings to prevent deflection during installation. Provide stulls consisting of timber struts with end blocks shaped to fit curvature of interior surface of pipe or other appropriate configuration and material. Firmly edge and secure stulls to blocks so that they shall remain intact position during handling and installation. Provide stulls adequate to resist loads encountered without structural failure to stull members or damage to pipe. Where applicable, place stulls at such lengths so as to elongate vertical diameter of pipe as required to suit trench conditions encountered.
3. Handling and Storage: Install padded struts or stulls prior to shipping, horizontally and vertically at ten foot (10 Ft) intervals or as proposed by manufacturer and approved by the Project Manager. Spiders: Installed in joint ends of fittings. Stulls to remain in place, horizontally and vertically positioned under following conditions:
   a. During storage and shipping.
   b. Until welding is complete.
4. Reject and remove immediately from site pipe that arrives at site with defects in lining, including sand pockets, voids and oversanded areas.
5. Store pipe at job site with securely fastened plastic endcaps to maintain moist pipe interior. Promptly replace damaged endcaps to avoid shrinkage or cracking of cement-mortar lining.
6. Immediately replace damaged plastic end caps. Do not leave uncapped for more than four hours (4 Hrs).
7. Bedding and Backfilling:
   a. Conform to requirements of Section 02125 – Excavation and Backfill for Utilities.
   b. Align pipe at proper grade prior to joint connection and do not shift after jointing operation has been completed.

c. Take necessary precautions during bedding and backfilling operations to prevent deformation or deflection of cylindrical shape of pipe by more than allowable pipe deflection. Do not move trench support system (trench safety system) once bedding material is compacted.

d. Excavate outside specified trench section for bell holes and for spaces sufficient to permit removal of slings. Provide bell holes at proper locations for unrestricted access to joint. Form bell holes large enough to facilitate joint wrapping and to permit visual examination of process. Enlargement of bell holes as required or directed by the Project Manager. Subsequent backfilling thereof shall not be considered as authorized additional excavation and backfill. Backfill bell holes and spaces to satisfaction of the Project Manager.

e. Blocking may be removed twenty-four hours (24 Hrs) after placing backfill to top of pavement or natural ground level.

8. Pipe Deflection: After backfill is complete, test pipe for excessive deflection by measuring actual inside vertical diameter. For maximum deflection allowable, see Section 2.1.H.8.

a. Deflection may be measured by the Project Manager at location along pipe. Arithmetical averages of deflection are not acceptable.

b. If deflection exceeds that specified, do one (1) of the following:

1) Remove backfill and side support. Re-round the pipe and properly replace compacted backfill and side support. Review cement mortar lining to assure that no harmful damage has occurred.

2) Remove entire portion of deflected pipe section and install new pipe as directed by the Project Manager at no additional cost to the City.

9. Move pipe in such manner not to damage pipe or coating. Do not roll pipe nor drag on ground. Inspect and repair coating abrasions before pipe is lowered into trench.

10. Use of dogs, clips, lugs or equivalent devices welded to steel pipe for purpose of forcing it into position shall not be permitted unless approved by the Project Manager. Remove foreign matter and protective material from surfaces that are to be in contact at joints. Leave surfaces of joint areas thoroughly clean for metal-to-metal contact of field joints.

C. Static Electricity:

1. Properly ground steel pipeline during construction as necessary to prevent build-up of static electricity.

2. Electrically test where required after installation of pipeline is complete.

D. Deviation of installed pipe in one pipe section from line and grade shown on approved shop drawing layout shall not exceed two inches (2 In) from grade and three inches (3 In) from line. No deviation from line and grade at contact interfaces are allowed.

E. Use adequate surveying methods, procedures and employ competent surveying personnel to ensure pipe sections are laid to line and grade and within stipulated tolerances. Measure and record, in form approved by the Project Manager and submit copy of data to the Project Manager at end of that day. Survey data to include unique pipe number, deflection angle at pipe joint and whether beveled ends were used, invert elevation at pipe joint, deviation of joint from project line, deviation of joint from project grade, inside pipe joint lap measured at top, bottom and at springline (each side).

F. Any time that laying of additional pipe is stopped for more than eight hours (8 Hrs); plug ends of installed pipe and take proper precautions against flotation of pipe segments.

3.2 EXTERNAL COATING SYSTEM FOR STEEL PIPE INSTALLED ABOVE GROUND AND IN VAULTS (EXPOSED) AND EPOXY INTERNAL LINING SYSTEM

A. Safety: Paints, coatings and linings specified in this Section are hazardous materials. Vapors may be toxic or explosive. Protective equipment, approved by appropriate regulatory agency, is mandatory for personnel involved in painting, coating and lining operations.

B. Workmanship:
1. Application: By qualified and experienced workers who are knowledgeable in surface preparation and application of high-performance industrial coatings.
2. Paint Application Procedures: SSPC Good Painting Practices, Volume 1.

C. Surface Preparation:
1. Use abrasive blasting to prepare surfaces.
2. Schedule cleaning and painting so that detrimental amounts of dust or other contaminants do not fall on wet, newly-painted surfaces. Protect surfaces not intended to be painted from effects of cleaning and painting operations.
3. Prior to blasting, clean surfaces to be coated or lined of grease, oil and dirt by steaming or detergent cleaning in accordance with SSPC SP1.
4. Metal and Weld Preparation: Remove surface defects such as gouges, pits, welding and torch-cut slag, welding flux and spatter by grinding to one-quarter inch (1/4 In) minimum radius.
5. Abrasive Material:
a. Blast only as much steel as can be coated within same

day of blasting.

b. Use sharp, angular, properly graded abrasive capable of producing depth of profile specified herein. Transport abrasive to jobsite in moisture-proof bags or airtight bulk containers. Copper slag abrasives are not acceptable.

c. After abrasive blast cleaning, verify surface profile with replica tape such as Tes-Tex Coarse or Extra Coarse Press-O-Film Tape or approved equal. Furnish tapes to the Project Manager.

d. Do not blast if metal surface may become wet before priming commences or when metal surface is less than five degrees Fahrenheit (5° F) above dew point.

6. Evaluate degree of cleanliness for surface preparation with use of SSPC Pictorial Surface Preparation Standards for Painting Steel Surfaces, SSPC Vis1.

7. Remove dust and abrasive residue from freshly blasted surfaces by brushing or blowing with clean, dry air. Test cleanliness by placing three-quarters inch by four inch (3/4 In x 4 In) piece of clear Scotch-type tape on blasted surface, then removing and placing tape on three inch by five inch (3 In x 5In) white index card. Re-clean areas exhibiting dust or residue.

D. Coating and Lining Application:

1. Environmental Conditions: Do not apply when metal temperature is less than fifty degrees Fahrenheit (50° F); when ambient temperature is less than five degrees Fahrenheit (5° F) above dew point; when expected weather conditions are such that ambient temperature shall drop below forty degrees Fahrenheit (40° F) within six hours (6 Hrs) after application; or when relative humidity is above eighty-five percent (85%). Measure relative humidity and dew point by use of sling psychrometer in conjunction with U.S. Department of Commerce Weather Bureau Psychometric Tables. Provide dehumidifiers for field-applied coatings and linings to maintain proper humidity levels.

2. Application Procedures:

a. Apply in accordance with manufacturer's recommendations and requirements of this Section. Provide finish free of runs, sags, curtains, pinholes, orange peel, fish eyes, excessive over spray or delaminations.

b. Thin materials only with manufacturers recommended thinners. Thin only amount required to adjust viscosity for temperature variations, proper atomization and flow-out. Mix material components using mechanical mixers.

c. Discard catalyzed materials remaining at end of day.

3. Thoroughly dry pipe before primer is applied. Apply primer

immediately after cleaning surface. Apply succeeding coats before contamination of undersurface occurs.

4. Cure minimum of twenty-four hours (24 Hrs) at seventy-seven degrees Fahrenheit (77° F) before successive coats are applied. During curing process, provide force air ventilation in volume sufficient to maintain solvent vapor levels below published threshold limit value. Apply successive coats within recoat threshold time as recommended by coating or lining manufacturer on printed technical data sheets or through written communications. Brush blast joints of pipe which have been shop primed and are to receive intermediate and finish coats in field prior to application of additional coats. After interior coats are applied, provide forced-air ventilation in sufficient volume and for sufficient length of time to ensure proper curing before filling pipe with water.

3.3 EXTERNAL COATING SYSTEM FOR BURIED STEEL PIPE

A. Tape Coating System:

1. Joint Protection

a. Coating field joints, tie-ins and other field-welded joints: Provide application of approved insulating putty at bell step-offs and two (2) wraps of Field Joint Tape Primer: Furnished by tape manufacturer.

b. At the Contractor's option, apply approved special heat resistant tape system prior to internal welding of pipe. Coat entire pipe with shop-applied tape. Coat bell end with shop-applied heat-resistant tape. In field, fill joint step off area with insulating putty. Field apply two (2) layers of field joint tape over joint followed by high shear strength outerwrap. Follow manufacturer's recommendation for field-applied tape coating.

c. At the Contractor's option, provide field-applied shrink-wrap coating system for coating field joints, tie-ins and other field welded joints. Apply heat-shrink sleeves prior to internal welding of pipe using approved procedure compatible with coating system. Install heat-shrink joint sleeves in accordance with manufacturer's recommendations. Provide shrink-wrap systems consisting of primer, tape coating and polyurethane coating and high-strength application of Aqua-shield Wrap for pipeline. Provide services of technical representative of manufacturer available on site at beginning of pipelaying operations. Representative to advise the Contractor and the Project Manager regarding installation, repairs and general construction methods.

2. Field Application: AWWA C209 around joint cutbacks except as modified:
   a. Field-welded joints: Clean shop-primed ends of weld splatter, damaged primer and rust to achieve required surface preparation prior to field repair of coatings.
   b. Extend joint cleaning four inches (4 In) onto existing coating. Completely remove damaged and loose end-coatings.
   c. Prior to placing pipe in trench, remove shop-applied primer by abrasive blasting, solvent or other method as approved by the Project Manager. Avoid damage to adjacent existing coatings.
   d. Clean surfaces to achieve surface preparation at least equivalent to SSPC SP6 in accordance with AWWA C209. Provide solvent that is environmentally safe and compatible with coating system primer.
   e. Apply insulating putty onto bell step-off as shown on the Drawings. Remove release liner during application.
   f. Apply primer immediately prior to application of first layer of tape to achieve maximum bond. Apply tape while primer is still "tacky" with three inch (3 In) minimum overlap over shop-applied coating.
3. Joint Tape
   a. Extend inner wrap minimum of two inches (2 In) onto existing coating on each side of joint. Extend outer wrap minimum of four inches (4 In) onto existing coating each side of joint. Stagger end laps minimum of six inches (6 In). Overlap adjacent tape wraps at least one inch (1 In) and overlap seam of outer wrap. Do not allow to be coincident with overlap seam of inner wrap. Wash with Xylol area that shall be overlapped.
   b. Apply approved joint wrap tape to uncontaminated primer at proper roll body temperature. If necessary, store joint wrap material in heated box up to point of application.
   c. Apply joint wrap material to pipe in either spiral or cigarette fashion dependent upon specification. Begin wrapping process two inches (2 In) to four inches (4 In) onto mill-applied pipe wrap and proceed wrinkle-free up over bell and across joint to spigot side pipe wrap.
   d. Apply joint wrap under machine tension of five pounds (5 Lbs) to ten pounds (10 Lbs) per inch width. Joint wrap width should narrow (neck down) as material is applied tightly around pipe.
   e. Apply first one-third (1/3) and last one-third (1/3) turn of joint material around pipe with less tension to prevent

wrap crawlback. Overlap of joint wrap material and system's total thickness as specified in this Section.

f. End joint wrap process such that its final edge is directed downwards when pipe is placed in ditch to prevent backfill from pulling exposed joint wrap edge.

4. Do not expose tape coatings or heat-shrinkable joint sleeves to harmful ultraviolet light for more than ninety days (90 D). Discard (remove) and replace outer layer of tape coating when exposure exceeds ninety days (90 D). In case of factory-applied coatings, remove pipe from site for removal and reapplication of outer layer of tape coatings.

5. At option of the Project Manager, coating system and application may be tested and inspected at plant site in accordance with AWWA C214.

B. Test for holidays:

1. Inspect pipe for holidays and damage to coating.

a. If test indicates no holidays and outer wrap is torn, remove damaged layers of outer wrap by carefully cutting with sharp razor-type knife. Wash with Xylol area to be patched and at least four inches (4 In) of undamaged tape where hand-applied tape wrap shall overlap. AWWA C209 cold-applied tape compatible with tapewrapping system applied for each layer of outer-wrap tape that has been removed.

b. If test indicates holiday, remove outer layers and expose inner wrap. Prime exposed area and overlaps with light coat of primer. Firmly press into place patch of two (2) thirty-five (35) mil inner wrap tape extending four inches (4 In) from affected area in all directions. Second patch to overlap first patch by two inches (2 In). Perform holiday test of patch to verify satisfactory installation. Wash exposed outer wrap tape with Xylol and prime.

c. For severe outer wrap tape tears or damage and holiday is not detected, remove outer wrap to boundaries of damaged area, taking care not to damage inner wrap coating. Before replacing outer wrap, apply holiday detector to exposed area to determine that no damage has been made to primary coating. After verification that no holidays exist in underlying tape, clean damaged area and use patch of thirty-five (35) mil outer wrap tape. Apply as specified herein for repair of areas where bare pipe is exposed.

2. Do not allow bubbles in tape coating system regardless of holiday test results, cut out bubbles and patch as described above as directed by the Project Manager.

3. Perform test procedure in accordance with NACE Standard RP-

02-74. Perform electrical holiday test with sixty (60) cycle current audio detector. Use test voltage as specified in TABLE 4.5 TEST VOLTAGES in this Section.

C. Remove areas having physical damage and recoat. After repairing area, apply holiday detector as stated above to verify area is adequately repaired.

D. Cement mortar coating. AWWA C205; one inch (1 In) minimum thickness; Cut back from joint ends no more than two inches (2 In) to facilitate joining and welding of pipe.

3.4 JOINTS AND JOINTING

A. Rubber Gasketed Bell-and-Spigot Joints.

1. Use O-ring gasket with sufficient volume to approximately fill area of groove and gasket material in accordance with AWWA C200. Check each splice in gasket by stretching gasket to at least twice original length of gasket. Visually check stretched splice by rotating three hundred sixty degrees (360°). Reject splices showing visible separation or cracks.
2. Equalize rubber gasket cross section after rubber gasket is placed in spigot groove of pipe by inserting tool or bar such as large screwdriver under rubber gasket and moving it around periphery of pipe spigot. Lubricate gaskets with nontoxic water-soluble lubricant before pipe units are joined. Fit pipes together in manner to avoid twisting or otherwise displacing or damaging rubber gasket. Check gaskets after pipe sections are joined with feeler gauge to ensure that no displacement of gasket has occurred at point around circumference after joining. If displacement has occurred, remove pipe section and remake joint as if for new pipe. Remove old gasket and replace before remaking joint.

B. Welded Joints:

1. Conform to requirements of Section 02400 – Water Lines.
2. Field weld to be double-welded lap field joints or full penetration butt welded joints for steel pipe and encasement sleeves for entire circumference.
3. Employ independent certified testing laboratory, approved by the Project Manager, to perform weld acceptance tests on welded joints. Include cost of such testing in contract the unit price bid for water line. Furnish copies of all test reports to the Project Manager for review. Test by magnetic particle test method for lap welds and fillet welds or by X-ray methods for butt welds, for one hundred percent (100%) of all joint welds. The Project Manager has final decision as to suitability of welds tested.

C. Flanged Joints: Conform to requirements of Section 02400 – Water Lines.

D. Joint Grouting and Testing: Conform to requirements of Section 02400

– Water Lines.

E. Do not allow steel plugs for threaded outlets to project beyond inner surface of pipe shell and seal weld by at least two (2) passes. Apply weld around outside of plug after it has been inserted in final position. Coat outlets and plugs inside and outside as required at field joints on pipe.

3.5 FIELD-APPLIED CEMENT-MORTAR LINING

A. Entrances Into Pipeline:

1. Establish means to permit entry and exit of labor, materials and equipment necessary for progress of work, as approved by the Project Manager.
2. Provide dikes and channeling for diversion of flood and drainage waters away from these openings in pipeline. Use temporary airtight covers over openings to provide proper curing conditions in completed sections of lined pipe. Where operation of equipment requires that end of pipe be left open, install temporary bulkhead inside pipe to eliminate direct draft through pipe over completed sections.
3. Brace closure sections of pipeline left out to facilitate field lining above ground to conform as nearly as possible to shape of pipe in ground and then place cement-mortar lining by machine or hand trowel to same thickness as in adjoining machine-lined sections. Bulkhead sections immediately after being lined to maintain proper curing conditions for period of not less than forty-eight hours (48 Hrs) before sections are installed in pipeline. Install these sections of steel pipe.
4. Coat exterior surface of buttstraps and uncoated exterior surface area of steel pipe within excavations in accordance with the Technical Specifications. Place cement-mortar lining inside areas of joints in accordance with the Technical Specifications.

B. Mixing of Cement-mortar: Mix ingredients for cement-mortar for not less than one and one-half minutes (1-1/2 Min) and not more than six minutes (6 Min); use mortar promptly after mixing for lining pipe. Do not use mortar that has attained its initial for lining. Do not re-temper mortar. Add water to mix last.

C. Placing Cement-mortar Lining:

1. Complete joint work, backfill and welding before cement-mortar lining begins. After cement-mortar lining has cured hydrostatic testing of pipe can begin.
2. Provide provisions necessary for the Project Manager to conduct inspections of work in safe and thorough manner during and after initial application of mortar and after necessary repairs made. Include, as minimum, space on application machine and adequate lighting to inspect gross surface areas
3. Comply with ASTM C494 and with manufacturer's recommendations when using chemical admixtures, bonding

agents, accelerators and other additives.

4. Remove dirt, debris, oil, grease and loose mill scale and rust from interior surfaces of pipe and scrape or brush surface with stiff bristle brush and/or water blast as may be necessary and approved by the Project Manager, to ensure clean surfaces for successful application of cement-mortar lining. Interior surfaces to be approved by the Project Manager prior to placing lining.
5. Provide cement-mortar lining uniform in thickness along entire length of pipe. Provide cement-mortar no less than one-half inch (1/2 In) over all surfaces with tolerance of plus one-eighth inch (+1/8 In) and no allowance for minus tolerance.
6. Mechanically control travel of machine and rates of discharge of mortar to produce uniform thickness of lining without segregation around perimeter and along length of pipe.
7. Check finished surface by placing twelve inch (12 In) straightedge parallel to axis of pipe along surface of straight section of lining. At no point shall space between lined surface and straightedge be greater than one-sixteenth inch (1/16 In).
8. Provide smooth finished surface, within tolerances specified. Repair or replace surface irregularities including corrugations, ripples or pits in any direction, to satisfaction of the Project Manager. Remove defective lining material, including, sand pockets, voids, oversanded areas, blisters, delaminations or unbounded areas, cracked areas, irregular surfaces and unsatisfactory thin spots. Remove to pipe wall and area repaired to full thickness of mortar lining.
9. Repair cracks one-sixteenth inch (1/16 In) and larger to satisfaction of the Project Manager.
10. Place cement-mortar lining by machine having following features:
    a. An applicator head which can be centered within pipe and which shall centrifugally project mortar against wall of pipe at high velocity producing dense, uniformly distributed mortar on wall of pipe.
    b. Equipped with mechanically driven, rotating steel trowels that immediately follow applicator, providing smooth, hard surface without spiral shoulders. Compensate for torque so that machine shall sit true in pipe and trowel faces shall not vary in angle with mortar face during complete three hundred sixty degree (360°) cycle. Clean trowels at frequent intervals to prevent accumulated mortar from obtaining initial set resulting in sanded or unglazed finish. Continuously operate trowels during application of cement-mortar and forward progress of lining machine.

c. Design applicator so that nothing shall come in contact with troweled surface until it has attained final set and so that forward progress of machine and mechanical placing of mortar can be controlled to assure uniform thickness of lining.

11. Cement-mortar Lining: Adhere to steel at all points; provide consistent thickness except that lining of bell end of pipe where lining is to be thicker in order to fill depression and make smooth surface.
12. Immediately prior to application of cement-mortar lining, sweep and clean off slime, dirt, loose rust, loose mill scale and other foreign materials. Free interior surface of pipe after cleaning of accumulated water on pipe wall or at joints.
13. After receiving its finish troweling, do not roughen lining by rebound material or by mortar direct from machine.
14. Temporarily close outlets in pipeline with easily removable stoppers to prevent spun mortar from being thrown into such openings. After lining is applied, remove stoppers from outlets and repair lining damaged by removal of stoppers. Point outlet openings up to provide smooth flow.

D. Hand Finishing:
1. Repair defective areas in machine-applied lining and unlined joints by hand patching to yield lining equal to that required for machine-applied troweled lining.
2. Provide nonshrink grout for patching or lining joints as specified in this Section.
3. Clean defective areas of loose foreign material and moisten with water just prior to application of hand-applied mortar.
4. Use steel finishing trowels for hand application of cement-mortar.
5. Complete hand finishing required in given pipe section not later than day following machine application of mortar lining to that particular pipe section, whether normal working day or otherwise. Slow down or stop machine application of mortar lining to allow time for hand patching.

E. Curing of Lining: Begin curing operations immediately after completing any portion of mortar lining. Close pipe by airtight bulkheads and maintain moist atmosphere in completed section of pipe to keep lining damp and to prevent evaporation of entrained water from mortar lining. Humidify air introduced into pipe for ventilating or curing purposes and maintain moist atmosphere inside pipe until the Project Manager accepts the Work.

3.6 INSPECTION (EXCEPT MORTAR COATED PIPE)

A. Include cost of inspection described in Paragraph 3.7, Inspection, in contract the unit price for water line. Furnish copies of certified inspection reports to the Project Manager for review.

B. Holiday Test and Adhesion Test: Provide services of independent coating and lining inspection service or testing laboratory with qualified coating inspectors. Provide inspections by NACE trained inspectors under supervision of NACE Certified Coatings Inspector having Level III Certification.

3.7 COATINGS AND LININGS INSPECTION RESPONSIBILITIES

A. The Contractor is responsible for quality control of coatings and linings applications and testing and inspection stipulated in this Section. The Project Manager is responsible for quality assurance and reserves right to inspect or acquire services of independent third-party inspector who is fully knowledgeable and qualified to inspect surface preparation and application of highperformance coatings at phases of coatings and linings, field or shop applied. The Contractor is responsible for proper application and performance of coatings and linings whether or not the Project Manager provides such inspection.

B. Cement Mortar Lining and Joint Finish: Finished surface of lining and joint to be comparable to surface rubbed with No. 16 Carborundum stone. Rub joint mortar sufficiently to bring paste to surface, to remove depressions and projections and to produce smooth, dense surface. Add cement to form surface paste as necessary. Leave interior with clean, neat and uniform-appearing finish.

3.8 FIELD REPAIR PROCEDURES AND SPECIAL FITTINGS APPLICATION FOR CEMENT MORTAR LINING

A. Areas less than or equal to six inches (6 In) in diameter: Patch honeycomb and minor defects in concrete surfaces with nonshrink grout. Repair defects by cutting out unsatisfactory material and replacing with nonshrink grout, securely bonded to existing concrete. Finish to make junctures between patches and existing concrete as inconspicuous as possible. After each patch has stiffened sufficiently to allow for greatest portion of shrinkage, strike off grout flush with surrounding surface.

B. Areas greater than six inches (6 In) in diameter:

1. Remove defective lining down to bare steel by chipping, making sure care is taken to prevent further lining damage. Ends of lining where defective lining is removed are to be left square and uniform not feathered.
2. Clean bare steel with wire brush to remove loose or other foreign matter.
3. Remove existing wire reinforcement and replace. Overlap new reinforcement to existing reinforcement by one-half inch (1/2 In). Secure reinforcement, against wall of pipe, at frequent intervals, by tack welding to pipe.
4. Prepare cement mortar mixture. Mixture to compose of Portland Type II cement, sand and water. Proportions of sand to cement not to exceed three (3) parts sand to one (1) part cement, by

weight. Use only enough water to obtain proper placement characteristics. Set up time before mixture is to be discarded is to be no longer than one-half hour (1/2 Hr). Nonshrink grout may also be used. Do not use combination of cement mortar and nonshrink grout within same repair.

5. Apply WELD-CRETE or approved equal, concrete bonding agent to bare steel and interface of existing lining. After bonding agent is applied to steel and lining new mix must be applied within ten minutes (10 Min).
6. Apply cement mortar to repair area one-half inch (1/2 In) thick then hand trowel to achieve smooth dense finish, making sure wire is not left exposed. To ensure proper thickness while placing new mortar, check thickness with one-half inch (1/2 In) long wire gauge.
7. Curing: Place plastic sheeting over repair area, use tape to adhere plastic to area surrounding repair area. Let cure for four days (4 D) then remove plastic sheeting.

PART IV: TABLES

4.1 PIPE WALL THICKNESSES

Net Inside Diameter (Inches)	Minimum Wall Thickness (Inches)	
	Flexible Coating	Mortar Coating
24	0.149	0.136
30	0.149	0.136
36	0.178	0.163
42	0.207	0.189
48	0.235	0.215
54	0.271	0.250
60	0.301	0.268
66	0.333	0.295
72	0.362	0.320
78	0.393	0.359
84	0.423	0.395
90	0.454	0.430
96	0.484	0.464

4.2 – REQUIRED BENDS STOCK

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

* Based on total length of contract [minimum of four (4)]). Any combination of bends may be substituted at manufacturer's option [i.e. two (2) – twenty-two and one half degree (22-1/2°) bends are equivalent to one (1) – forty-five degree (45°) bend] and shall be counted as one (1) fitting.

4.3 – EPOXY PRIMER FOR INTERIOR SURFACES

Surface Preparation	**SSPC SP5 White Blast Clean 2.0 to 3.0 mils surface profile**
Prime Coat 4.0 to 6.0 mils DFT	NSF Certified Epoxy – Buff or approved equal
Intermediate Coat 4.0 to 6.0 mils DFT	NSF Certified Epoxy – Buff or approved equal
Finish Coat 4.0 to 6.0 mils DFT	NSF Certified Epoxy – White or approved equal

4.4 – THREE COAT EPOXY/POLYURETHANE COATINGS

Surface Preparation	**SSPC SP10 Near White Blast Clean 2.0 to 3.0 mils surface profile**
Prime Coat 4.0 to 6.0 mils DFT	Inhibitive Epoxy Primer of approved equal
Intermediate Coat 4.0 to 6.0 mils DFT	Chemical Resistant Epoxy or approved equal
Finish Coat 1.5 to 2.5 mils DFT	Polyurethane or approved equal

4.5 TEST VOLTAGES

Total Coating Thickness (Mils)	**Test Voltage (Volts)**
20	6,000
30/35	7,500
50	9,000
70	11,500
80	12,000

END OF SECTION