Section 02518

STEEL PIPE AND FITTINGS FOR LARGE DIAMETER WATER LINES

PART 1 G E N E R A L

1.1 SECTION INCLUDES

1. Large diameter (24 inches and greater) steel pipe and fittings for water lines and pumping facilities.

1.2 MEASUREMENT AND PAYMENT

1. Unit Prices.

    1. No payment will be made for steel pipe and fittings under this Section. Include cost in unit price for water lines, pumping facilities, and encasement sleeves.

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

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

1.3 REFERENCES

1. AASHTO - Standard Specifications for Highway Bridges.

2. AREMA - Manual for Railway Engineering, Volume II, Chapter 15.

3. ASTM A 36 - Standard Specification for Structural Steel.

4. ASTM A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.

5. ASTM A 135 - Standard Specification for Electric-Resistance-Welded Steel Pipe.

6. ASTM A 139 - Standard Specification for Electric-Fusion (ARC) - Welded Steel Pipe (NPS 4 and Over).

7. ASTM A 570 - Standard Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality.

8. ASTM C 33 - Standard Specification for Concrete Aggregates.

9. ASTM C 35 - Standard Specification fro Inorganic Aggregates for Use in Gypsum Plaster.

10. ASTM C 150 - Standard Specification for Portland Cement.

11. ASTM C 494 - Standard Specification for Chemical Admixtures for Concrete.

12. ASTM C 595 - Standard Specification for Blended Hydraulic Cements.

13. ASTM C 881 - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.

14. ASTM C 1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).

15. ASTM D 512 - Standard Test Methods for Chloride Ion in Water.

16. ASTM D 1293 - Standard Test Methods for pH of Water.

17. ASTM D 3363 - Standard Test Method for Film Hardness by Pencil Test.

18. ASTM D 4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Tests.

19. ASTM D 4752 - Standard Test Method for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub.

20. AWWA C 200 - Steel Water Pipe 6 in. and Larger.

21. AWWA C 205 - Cement-Mortar Protective Lining and Coating for Steel Water Pipe.

22. AWWA C 206 - Standard for Field Welding of Steel Water Pipe.

23. AWWA C 207 - Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 in. through 144 in.

24. AWWA C 208 - Dimensions for Fabricated Steel Water Pipe Fittings; Addendum C 208A.

25. AWWA C 209 - Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections and Fittings for Steel Water Pipelines.

26. AWWA C 210 - Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.

27. AWWA C 214 - Tape Coating Systems for the Exterior of Steel Water Pipelines.

28. AWWA C 602 - Cement-Mortar Lining of Water Pipelines - 4 in. (100 mm) and Larger - In Place.

29. AWWA M 11 - Steel Pipe-A Guide for Design and Installation.

30. SSPC Good Painting Practice, Volume 1.

31. SSPC SP 1 - Surface Preparation Specification No. 1 Solvent Cleaning.

32. SSPC SP 5 - Joint Surface Preparation Standard White Blast Cleaning.

33. SSPC SP 6 - Surface Preparation Specification No. 6 Commercial Blast Cleaning.

34. SSPC SP 10 - Surface Preparation Specification No. 10 Near-White Blast Cleaning.

35. SSPC VIS 1 - Visual Standard for Abrasive Blast Cleaned Steel.

1.4 SUBMITTALS

1. Conform to requirements of Section 01330 - Submittal Procedures.

2. Submit shop drawings signed and sealed by Professional Engineer registered in 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 Drawings. Do not start production of pipe and fittings prior to review and approval by City Engineer. 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 professional Engineer registered in State of Texas.

3. Submit manufacturer's certifications that pipe and fittings have been hydrostatically tested at factory in accordance with AWWA C 200, Section 3.4.

4. 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.

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

6. Submit following for nonshrink grout for special applications:

    1. Manufacturer's technical literature including specifications for mixing, placing, and curing grout.

    2. Results of tests performed by certified independent testing laboratory showing conformance to ASTM C 1107, Nonshrink Grout and requirements of this specification.

    3. Certification product is suitable for use in contact with potable water.

7. 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 6 months in accordance with AWWA C206.

8. Within 45 calendar days after manufacturing of all pipe, submit affidavit of compliance that materials and work furnished comply with applicable requirements of referenced standards and these specifications. Make available copy of physical and chemical testing reports.

9. Within 45 days 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 5 degrees above dew point.

    2. Mortar coatings and linings were applied and allowed to cure at temperature above 32 degrees F.

    3. Test Results

        1. Compressive strength (7 and 28 day) test results for mortar coating.

        2. Hydrostatic testing, magnetic particle and x-ray weld test reports as required

10. 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 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.

11. Submit certification showing calibration within last 12 months 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 City Engineer.

1.5 QUALITY CONTROL

1. 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 City Engineer. Perform manufacturers tests and inspections required by referenced standards and these Specifications, including the following. Correct nonconforming conditions.

    1. Steel Plate and Coils: Review mill certifications for conformance to requirements of Specifications; perform physical and chemical testing of each heat of steel for conformance to applicable ASTM standards.

    2. Pipe:

        1. Inspect thickness, circumference, roundness, strength and size of seam welds (spiral or longitudinal), and squareness of pipe ends to verify compliance with AWWA C200.

        2. Inspect physical dimensions and overall conditions of all joints for compliance with AWWA C200, approved submittals, and Specifications.

        3. Hydrostatically test finished pipe section to 75 percent of specified minimum yield strength of steel being used with zero leakage.

        4. For wall thickness greater than 2-inch preform Charpy V-Notch (CVN) Test in accordance with AWWA C200.

    3. Linings:

        1. Inspect unlined pipe for overall condition of inside barrel. Maintain inside barrel free of corrosive products, oil, grease, dirt, chemical, and deleterious material.

2. Inspect lined pipe for physical dimensions and overall condition of lining, visible surface defects, thickness of lining, and adhesion to steel surface.

3. Review certifications by Manufacturer's of lining components for conformance to AWWA standards and these 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:

1. Before shipment, inspect finished pipe, fittings, specials and accessories for markings, metal, coating thickness, lining thickness (if shop applied), joint dimensions, and roundness.

2. Inspect for coating placement and defects. Test exterior coating for holidays.

3. Inspect linings for thickness, pitting, scarring, and adhesion.

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

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

4. Cast four standard test cylinders each day for each 50 cubic yards of mortar coating or portion thereof for each coating and lining placed in a day. Perform compressive strength test at 28 days. No cylinder test result will be less than 80 percent of specified strength.

5. Dented steel cylinders will result in rejection of pipe.

6. Make available copy of physical and chemical testing reports for steel cylinders and provide reports at request of City Engineer.

7. 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

1. City Engineer may witness manufacture and fabrication of pipe and appurtenances. Independent testing laboratory under contract to City Engineer may perform tests at direction

of City Engineer to verify compliance with these specifications. Provide assistance to accomplish such testing, including equipment and personnel, at no additional cost to City.

PART 2 P R O D U C T S

1.7 STEEL PIPE

1. Furnish pipe by same manufacturer.

2. Furnish pipe smaller than 24-inch in accordance with Section 02502 - Steel Pipe and Fittings.

3. Fabricate and supply miscellaneous steel pipe and fittings with nominal diameter of 24 inches and larger in accordance with AWWA C200, C207, C208 and AWWA M11 except as modified herein. Steel to be minimum of ASTM A 36, ASTM A 570 Grade 36, ASTM A 53 Grade B, ASTM A 135 Grade B, or ASTM A 139 Grade B.

4. Provide pipe sections in lengths no greater than 40 feet and no less than 10 feet except as required for special fittings or closure sections.

5. Provide closure sections and short sections of steel pipe not less than 4 feet in length unless indicated on Drawings or specifically permitted by City Engineer.

6. Square flanges with pipe with bolt holes straddling both horizontal and vertical axis. Provide 2 -inch gap between pipe ends to be coupled with sleeve coupling unless otherwise indicated on 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.

7. 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 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 = 100 psi.

    4. Hydrostatic field test pressure = 150 psi.

    5. Maximum pressure due to surge = 150 psi.

6. Minimum pressure due to surge = -5 psi.

7. Modulus of elasticity (E) = 30,000,000 psi.

8. Maximum deflection from specified diameter: Two percent for mortar coating; three percent for flexible coatings and three percent for mortar lining.

9. Design stress due to working pressure to be no greater than 50 percent of minimum yield, and stress not to exceed 16,500 psi for mortar coated pipe.

10. Design stress due to maximum hydraulic surge pressure to be no greater than 75 percent of minimum yield, and stress not to exceed 24,750 psi for mortar coated pipe.

11. Modulus of soil reaction (EN) < 1500 psi. If EN > 1000 psi, do not use silty sand (SM) for embedment.

12. Unit weight of fill (w) > 120 pcf.

13. Deflection lag factor (D1) = 1.2.

14. Bedding constant (K) = 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 230.

17. Provide minimum inside clear diameter for tunnel liners or casing in accordance with Section 02425LD- Tunnel Excavation and Primary Liner.

18. Exclude structural benefits associated with primary liner in design of pipe in tunnel installations.

    1. Design pipe and joints to carry loads including overburden and lateral earth pressures, subsurface soil and water loads, grouting, other conditions of service, thrust of jacks, and stresses anticipated during handling and construction loads during installation of pipe.

    2. Do not use internal removable stiffeners for pipe in tunnel, unless approved by City Engineer.

    3. External welded steel stiffeners will be permitted in design calculations for steel pipe, provided wall thickness is minimum of 2 inch. Minimum clearances specified between exterior pipe wall and tunnel liner applies to distance between outside diameter of external welded stiffener and tunnel liner.

19. 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 16 feet. Net internal diameter (including inside linings) to be no less than net inside diameter listed. Contractor to review design for conditions more extreme than those indicated by this specification and design accordingly. If, in opinion of City Engineer, proposed pipe wall thicknesses appear inadequate for indicated loading conditions, submittal of design calculations will be required for review. Pipe wall not to be less than that defined in following table.

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

8. 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: 2-piece for 0 degrees to 22-1/2 degrees; 3-piece for 23 degrees to 45 degrees; 4-piece for 46 degrees to 67-1/2 degrees; and 5-piece for 68 degrees to 90 degrees, unless otherwise shown on 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 times pipe diameter.

5. Butt Straps for Closure Piece: Minimum 12-inch-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 4 inches between member being joined and edge of butt strap, welded on both inside and outside, unless otherwise approved by City Engineer. Provide minimum 6-inch welded outlet for inspecting each closure section, unless access manway is within 40 feet of closure section.

6. Joints are to be double-welded and butt or lap joints as shown on 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.

9. Joints:

1. Standard field joint for steel pipe: AWWA C206. Rubber gasket Carnegie shape joint or rolled-groove rubber gasket and O-ring joint, 66-inch 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 Drawings.

3. Pipe Manufacturer: Minimum of 5 years of successful service with proposed field joint or submit results from joint tests determined by City Engineer. 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. City Engineer's decisions 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 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.

    1. 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).

    2. 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 0.00 inch to 0.04 inch 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.

    3. Furnish joint suitable for safe working pressure equal to class of pipe and will operate satisfactorily with deflection, tangent of which is not to exceed 0.75 inch/D where D is outside diameter of pipe in inches or with pull-out of 3/4 inch.

    4. Design clearance between bells and gasketed spigots so, when joint is assembled, it will be self-centered and gasket will 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 will not be dependent upon water pressure in pipe and will provide watertight joints under operating conditions when properly installed.

10. Manufacturer must maintain on site or in plant enough fittings to satisfy the following requirements:

Line Diameter	Required Bends*
20 and 24 inches	Four 45E bends per 5,000 LF of water line
> 24 inches	Four 22.5E 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 22.5E bends are equivalent to one 45E bend) and will be counted as one fitting.	

11. Manufacturer must be capable of delivering bends to job site within 12 hours of notification. Use fittings at direction of City Engineer where unforeseen obstacles are encountered during

construction. These fittings are in addition to fittings called out on Drawings and must be available at all times. Use same product throughout entire project.

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

13. Hydrostatic Test of Pipe:

    1. AWWA C200, Section 3.5.3, at point of manufacture. Hold test for minimum 2 minutes and conduct thorough inspection of pipe. Repair or reject pipe revealing leaks or cracks.

    2. Calibrate pressure gauges within one year prior to testing as specified in Section 1.04 L.

14. 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.

15. 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 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 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 Drawings.

16. 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 50 percent 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.

17. Make curves and bends by deflecting joints, or by using beveled joints, or by combination of two methods, unless otherwise indicated on Drawings or permitted by City Engineer. 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 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 5 degrees.

1.8 INTERNAL LINING SYSTEMS FOR STEEL PIPE, ALL INSTALLATIONS

1. Supply steel pipe with either epoxy lining or cement-mortar lining, capable of conveying water at temperatures not greater than 140 degrees 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.

2. 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.

        1. Protect interior surface with liquid two-part chemically cured epoxy primer specified 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	ACRO 4460 NSF Certified Epoxy - Buff, or approved equal
Intermediate Coat 4.0 to 6.0 mils DFT	ACRO 4460 NSF Certified Epoxy - Buff, or approved equal
Finish Coat 4.0 to 6.0 mils DFT	ACRO 4460 NSF Certified Epoxy - White, or approved equal

    2. Total allowable dry film thickness for system:

        1. Minimum: 12.0 mils.

        2. Maximum: 18.0 mils.

    3. Provide dry film thicknesses for approved alternate products in accordance with products manufacturer recommendations.

    4. Lining system may consist of three or more coats of same approved alternate epoxy lining without use of separate primer.

    5. Perform adhesion test on pipe 48 inches in diameter and larger in accordance with ASTM D 4541. Minimum field adhesion: 700 psi. Perform test on pipe for project at frequency of one for every 1000 square feet of epoxy lining. Perform cure test in

accordance with ASTM D 4752 (solvent rub test) and ASTM D 3363 (pencil hardness) for each section of pipe. Repair tested areas with approved procedures.

3. Shop-applied Cement-mortar Lining:

    1. AWWA C205; except as specified herein: 2-inch minimum thickness for pipe diameters 42 inches and larger; 3/8-inch minimum thickness for pipe diameters 36 inches and smaller. Cut back lining from joint ends no more than 2 inches 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 Achair@ so wire does not fully rest against steel cylinder.

    4. Make repairs of cement-mortar lining for widths exceeding 6 inches by bonding to steel and adjacent faces of lining with bonding agent conforming to ASTM C 881, 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 City Engineer that above requirements can be accomplished by manufacturer prior to shipment of pipe.

4. Field-applied Cement-mortar Lining (for pipe $\geq$ 48 inches 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-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, receive cement-mortar lining.

    3. Cement-mortar for lining.

        1. Cement-mortar: Dense, smooth, and of uniform quality and consistency to assure efficient machine operation and uniform cement-mortar lining on pipe wall.

2. 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.

3. Mortar: Mixture of one part cement with not less than one or more than 1-1/2 parts of dry screened sand, by volume. After determining mixture, control materials to within plus or minus 2-1/2 percent by weight throughout entire work.

4. Comply with following materials for cement-mortar:

    1) Provide Type II low-alkali Portland cement conforming to ASTM C 150, or Type IP (MS) Portland-Pozzolan cement conforming to ASTM C 595, unless otherwise specified. Conform to low alkali requirements of Table IA of ASTM C 150. Type IP (MS) cement to contain no more than 20 percent Pozzolan, to be inter-ground with clinker.

    2) Use suitable facilities approved by City Engineer 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 City Engineer.

    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 specifications at least 10 calendar days before start of lining placement.

    7) Water: Clean; free of deleterious amounts of acids, alkalis or organic materials; total dissolved solids less than 1000 mg/l; ASTM D 512 chloride ions less than 100 mg/l for slurry and mortar cure; ASTM D 1293 pH greater than 6.5.

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

1. Provide 3-coat epoxy/polyurethane coating system as designated below. Provide materials from same manufacturer.

Surface Preparation	SSPC SP 10 Near White Blast Clean 2.0 to 3.0 mils surface profile
Prime Coat 2.0 to 4.0 mils DFT	ACRO 4422 Inhibitive Epoxy Primer, or approved equal
Intermediate Coat 4.0 to 6.0 mils DFT	ACRO 4460 Chemical Resistant Epoxy, or approved equal
Finish Coat 1.5 to 2.5 mils DFT	ACRO 4428 Polyurethane, or approved equal

2. Total Allowable Dry Film Thickness for System:

    1. Minimum: 7.5 mils.

    2. Maximum: 12.5 mils.

3. Perform adhesion test on pipe 48 inches in diameter and larger in accordance with ASTM D 4541. Minimum field adhesion: 700 psi. Perform test on pipe for project at frequency of one for every 1000 square feet of epoxy lining. Perform cure test in accordance with ASTM D 4752 (solvent rub test) and ASTM D 3363 (pencil hardness) for each section of pipe. Repair tested areas with approved procedures.

1.10 EXTERNAL COATING SYSTEMS FOR BURIED STEEL PIPE

1. Supply pipe with one of the following coatings specified.

    1. Tape Coating: Apply in accordance with AWWA C214 and requirements of this section; 80-mil shop-applied, Polyken YG-III, Tek-Rap Yard-Rap, or approved equal.

        1. Components: Primer, one 20-mil layer of inner-layer tape for corrosion protection and two 30-mil layers of outer-layer tape for mechanical protection.

        2. Where sleeve type or victaulic couplings are required, bond coupling to adjacent pipes with bonding cables as shown on Drawings.

3. Use filler putty type Polyken 939 insulating putty or approved equal to fill in gap and create smooth sloped transition between top of reinforcing plate and pipe, before tape coating is applied.

4. Primer: Compatible with tape coating, supplied by coating-system manufacturer.

5. Provide pipe with shop coatings cut back approximately 4 to 4-1/2 inches from joint ends to facilitate joining and welding of pipe. Taper successive tape layers by 1-inch staggers to facilitate field wrapping and welding of joints.

6. Inner and outer tape width: 12 or 18 inches.

7. Do not expose tape coating to direct sunlight for more than 60 days.

2. Cement-mortar Coating: AWWA C205; shop-applied, cement-mortar coating except as modified in this Section; 1-inch minimum thickness; cut back coating from joint ends no more than 2 inches to facilitate joining and welding of pipe.

3. Polyurethane Coating: See Section 02527 - Polyurethane Coatings on Steel or Ductile Iron Pipe for requirements for use of polyurethane coating system.

2. 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.

1.11 EXTERNAL COATING SYSTEM FOR STEEL PIPE IN TUNNEL, CASING

1. Provide exterior coating system of pipe in tunnel, without annular grout, as specified in Cement Mortar Coating for Buried Steel Pipe.

2. For water lines in tunnel where annular grout will be used, shop prime external surfaces of steel pipe with 3.0 to 4.0 mils DFT of ACRO 4422 Inhibited Epoxy Primer, or approved equal, unless pipe has cement-mortar coating.

1. Surface Preparation: SSPC-SP 10(64); Near White Blast Clean 2.0 to 3.0 mils surface profile.

2. Prime Coat: ACRO 4422 Inhibitive Epoxy Primer 3.0 to 4.0 mils DFT, or approved equal.

3. Use coating procedures and dry film thicknesses for approved alternate product in accordance with product manufacturer's recommendations.

1.12 GROUT FOR JOINTS AND SPECIAL APPLICATIONS

1. Cement Grout Mixture: One part cement to two 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 19 lb/gallon or greater as measured by grout/slurry balance. Use grout/slurry balance manufactured by Baroid or approved equal. Perform test in presence of and at request of City Engineer. 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 20 minutes and is not at proper specific gravity or moisture content.

    1. Portland Cement: ASTM C 150, Type II. Provide one type of cement for entire project.

    2. Sand:

        1. Interior joints: ASTM C 35 fine graded plaster sand.

        2. Exterior joints: ASTM C 33; natural sand with 100 percent passing No. 16 sieve.

    3. Water: Potable water with total dissolved solids less than 1000 mg/l; ASTM D 512 chloride ions less than 100 mg/l for slurry and mortar cure; ASTM D 1293 pH greater than 6.5. Use potable water with 250-ppm limit on chlorides and sulfates.

2. Nonshrink Grout for Special Applications, Patches and Repairs.

    1. Conform to requirements of ASTM C 1107, 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 C 1107 2500-psi minimum 7-day unconfined; 5000-psi minimum 28-day 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. Use EUCON N-S Grout as manufactured by Euclid Chemical Company, Cleveland, Ohio; Gilco Construction Grout as manufactured by Cormix Construction Chemicals, Dallas, Texas, or approved equal.

12. Mix, place, and cure in accordance with manufacturer's instructions and recommendations. Upon 72 hours' 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 used.

13. Mix cement grout to specific gravity of 17.7 lb/gallon or greater as measured by grout/slurry balance. Use grout/slurry balance manufactured by Baroid or approved equal. Perform test in presence of and at request of City Engineer. 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 20 minutes and is not at proper specific gravity or moisture content.

14. Compressive strength: ASTM C 1107 2500-psi minimum 7-day unconfined; 5000-psi minimum 28-day unconfined.

3. 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.

4. Joint Wrapper: Minimum width of 9 inches for 33-inch diameter and smaller; minimum width of 12 inches for diameters greater than 33-inch hemmed at edge to allow threading with minimum 5/8-inch wide steel strap. Provide minimum 6-inch wide Ethafoam strip sized, positioned, and sewn such that two circumferential edges of Ethafoam are 12-inches from outer edge of wrapper.

1.13 COLD-APPLIED TAPE COATING

1. 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 layers of prefabricated tape each 35 mils thick.

3. Overlap machine applied tape with hand-applied tape by minimum of two inches and bind to it.

4. Apply Polyken 30 mil filler tape 931, or approved equal parallel to spiral weld seams if weld height measures greater than or equal to 1/8 inch.

2. Surface Preparation

    1. Clean bare pipe from mud, mill lacquer, oil, grease, or other contaminants. Inspect and clean surfaces according to SSPC-SP-1 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.

1.14 EXTERNAL TAPE COATING SHOP APPLICATION

1. Separate tape-dispensing equipment far enough apart to visually inspect continuous steps.

2. Make cutbacks straight and for total thickness of coating.

3. 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.

4. Apply weld filler tape over primer and extend minimum of one inch 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.

5. Spirally apply inner layer of tape in direction of helix weld. Overlap each spiral of tape1 inch or greater with next successive spiral of tape applied.

6. Overlap end of new roll on top of previous roll minimum of 6 inches.

7. Tape roll body temperature to be greater than 70EF; pipe surface temperature to be greater than 60EF.

8. Spirally apply outer layer tapes in direction of helix weld and use overlap width and application tensions as recommended by manufacturer.

1.15 INSPECTION AND TESTING OF COATINGS

1. Perform electrical inspection on inner layer of tape before intermediate layer of tape is applied.

2. 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 2 inches. Perform electrical retest at repaired area after repairing holiday, and before outer wrap is continued.

3. Shrink Wrap: Perform electrical inspection on shrink-wrap to check for holidays. Perform peel tests over heat-affected zone. Minimum acceptable result: 15 lbs-ft/in.

PART 3 E X E C U T I O N

1.16 PIPING INSTALLATION

1. Conform to applicable provisions of Section 02511 - Water Lines, except as modified in this Section.

2. Comply with following:

    1. Make available services of Manufacturer's representative when deemed necessary by City Engineer. 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 will 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 10-foot intervals, or as proposed by manufacturer and approved by City Engineer. Spiders: Installed in joint ends of fittings. Stulls to remain in place, horizontally and vertically positioned under following conditions:

        1. During storage and shipping.

        2. 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 4 hours.

7. Bedding and Backfilling:

    1. Conform to requirements of Section 02317 - Excavation and Backfill for Utilities.

    2. Align pipe at proper grade prior to joint connection and do not shift after jointing operation has been completed.

    3. 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.

    4. 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 City Engineer. Subsequent backfilling thereof will not be considered as authorized additional excavation and backfill. Backfill bell holes and spaces to satisfaction of City Engineer.

    5. Blocking may be removed 24 hours 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 2.01.

    1. Deflection may be measured by City Engineer at location along pipe. Arithmetical averages of deflection are not acceptable.

    2. If deflection exceeds that specified, do one of the following:

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

2) Remove entire portion of deflected pipe section and install new pipe as directed by City Engineer at no additional cost to 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 will not be permitted unless approved by City Engineer. 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.

3. 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.

4. Deviation of installed pipe in one pipe section from line and grade shown on approved shop drawing layout will not exceed 2 inches from grade and 3 inches from line. No deviation from line and grade at contact interfaces are allowed.

5. 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 City Engineer and submit copy of data to City Engineer 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 spring line (each side).

6. Any time that laying of additional pipe is stopped for more than eight hours, plug ends of installed pipe and take proper precautions against flotation of pipe segments.

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

1. 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.

2. 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.

3. 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 SP 1.

   4. Metal and Weld Preparation: Remove surface defects such as gouges, pits, welding and torch-cut slag, welding flux and spatter by grinding to 1/4-inch minimum radius.

   5. Abrasive Material:

      1. Blast only as much steel as can be coated within same day of blasting.

      2. 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.

      3. 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 City Engineer.

      4. Do not blast if metal surface may become wet before priming commences, or when metal surface is less than 5 degrees F above dewpoint.

   6. Evaluate degree of cleanliness for surface preparation with use of SSPC Pictorial Surface Preparation Standards for Painting Steel Surfaces, SSPC-Vis 1.

   7. Remove dust and abrasive residue from freshly blasted surfaces by brushing or blowing with clean, dry air. Test cleanliness by placing 3/4-inch by 4-inch piece of clear Scotch-type tape on blasted surface, then removing and placing tape on 3x5 white index card. Reclean areas exhibiting dust or residue.

4. Coating and Lining Application:

   1. Environmental Conditions: Do not apply when metal temperature is less than 50 degrees F; when ambient temperature is less than 5 degrees F above dew point; when expected weather conditions are such that ambient temperature will drop below 40 degrees F within 6 hours after application; or when relative humidity is above 85 percent. 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:

    1. 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.

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

    3. 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 24 hours at 77 degrees 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 with ACRO 4460, or approved equal, 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.

1.18 EXTERNAL COATING SYSTEM FOR BURIED STEEL PIPE

1. Tape Coating System:

    1. Joint Protection

        1. Coating field joints, tie-ins, and other field-welded joints: Provide application of Polyken 939 Insulating Putty, or approved equal; at bell step-offs, and two wraps of Polyken 930-35 Field Joint Tape, or approved equal. Primer: Furnished by tape manufacturer.

        2. At Contractors option, apply modified tape coating system prior to internal welding of pipe. Coat entire pipe with shop-applied Polyken #989-20, Polyken #955-30 and Polyken #956-30. Coat bell end with shop-applied Polyken #2036-25 heat-resistant tape. In field, fill joint step off area with Polyken #935 insulating putty. Field apply two layers of Polyken #930-35 field joint tape

field joint tape over joint followed by Polyken #2055 high shear strength outerwrap. Follow Manufacturer's recommendation for field-applied tape coating.

3. At Contractors 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 pipe laying operations. Representative to advise Contractor and City Engineer regarding installation, repairs, and general construction methods.

2. Field Application: AWWA C209 around joint cutbacks except as modified:

1. 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.

2. Extend joint cleaning 4 inches onto existing coating. Completely remove damaged and loose end-coatings.

3. Prior to placing pipe in trench, remove shop-applied primer by abrasive blasting, solvent or other method as approved by City Engineer. Avoid damage to adjacent existing coatings.

4. Clean surfaces to achieve surface preparation at least equivalent to SSPC SP 6 in accordance with AWWA C209. Provide solvent that is environmentally safe and compatible with coating system primer.

5. Apply insulating putty onto bell step-off as shown on Drawings. Remove release liner during application.

6. Apply primer immediately prior to application of first layer of tape to achieve maximum bond. Apply tape while primer is still "tacky" with 3-inch minimum overlap over shop-applied coating.

3. Joint Tape

1. Extend inner wrap minimum of 2 inches onto existing coating on each side of joint. Extend outer wrap minimum of 4 inches onto existing coating each side of joint. Stagger end laps minimum of 6 inches. Overlap adjacent tape wraps at least 1 inch, and overlap seam of outer wrap. Do not allow to be coincident

with overlap seam of inner wrap. Wash with Xylol area that will be overlapped.

2. Apply joint wrap tape to uncontaminated primer at proper roll body temperature (e.g., 70 degrees F for POLYKEN 930, 934, 932). If necessary, store joint wrap material in heated box up to point of application.

3. Apply joint wrap material to pipe in either spiral or cigarette fashion dependent upon specification. Begin wrapping process 2 to 4 inches onto mill-applied pipe wrap and proceed wrinkle-free up over bell and across joint to spigot side pipe wrap.

4. Apply joint wrap under machine tension of 5 to 10 pounds per inch width. Joint wrap width should narrow (neck down) as material is applied tightly around pipe.

5. Apply first 1/3 and last 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 specification section.

6. 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 90 days. Discard (remove) and replace outer layer of tape coating when exposure exceeds 90 days. In case of factory-applied coatings, remove pipe from site for removal and reapplication of outer layer of tape coatings.

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

2. Test for holidays:

1. Inspect pipe for holidays and damage to coating.

1. 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 4 inches of undamaged tape where hand-applied tape wrap will overlap. AWWA C209 cold-applied tape compatible with tape-wrapping system applied for each layer of outer-wrap tape that has been removed.

2. 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 35-mil inner wrap tape (Polyyken930 or approved equal)

extending 4 inches from affected area in all directions. Second patch to overlap first patch by 2 inches. Perform holiday test of patch to verify satisfactory installation. Wash exposed outer wrap tape with Xylol and prime.

3. 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 35-mil outer wrap tape (Polyken 930 or approved equal). 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 City Engineer.

3. Perform test procedure in accordance with NACE Standard RP-02-74. Perform electrical holiday test with 60-cycle current audio detector. Use test voltage below:

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

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

1.19 JOINTS AND JOINTING

1. 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 360 degrees. 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

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.

2. Welded Joints:

    1. Conform to requirements of Section 02511 - 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 City Engineer, to perform weld acceptance tests on welded joints. Include cost of such testing in contract unit price bid for water line. Furnish copies of all test reports to City Engineer for review. Test by magnetic particle test method for lap welds and fillet welds or by X-ray methods for butt welds, for 100 percent of all joint welds. City Engineer has final decision as to suitability of welds tested.

3. Flanged Joints: Conform to requirements of Section 02511 - Water Lines.

4. Joint Grouting and Testing: Conform to requirements of Section 02511 - Water Lines.

5. Do not allow steel plugs for threaded outlets to project beyond inner surface of pipe shell and seal weld by at least two 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.

1.20 FIELD-APPLIED CEMENT-MORTAR LINING

1. Entrances Into Pipeline:

    1. Establish means to permit entry and exit of labor, materials and equipment necessary for progress of work, as approved by City Engineer.

    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 48 hours before sections are installed in pipeline. Install these sections of steel pipe.

4. Coat exterior surface of butt straps and uncoated exterior surface area of steel pipe within excavations in accordance specifications. Place cement-mortar lining inside areas of joints in accordance with specifications.

2. Mixing of Cement-mortar: Mix ingredients for cement-mortar for not less than 1-1/2 and not more than 6 minutes; use mortar promptly after mixing for lining pipe. Do not use mortar that has attained its initial for lining. Do not retemper mortar. Add water to mix last.

3. 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 City Engineer 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 C 494 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 City Engineer, to ensure clean surfaces for successful application of cement-mortar lining. Interior surfaces to be approved by City Engineer prior to placing lining.

5. Provide cement-mortar lining uniform in thickness along entire length of pipe. Provide cement-mortar no less than 2 inch over all surfaces with tolerance of plus 1/8 inch, 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 12-inch straightedge parallel to axis of pipe along surface of straight section of lining. At no point will space between lined surface and straightedge be greater than 1/16 inch.

8. Provide smooth finished surface, within tolerances specified. Repair or replace surface irregularities including corrugations, ripples, or pits in any direction, to satisfaction of City Engineer. 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 1/16 inch and larger to satisfaction of City Engineer.

10. Place cement-mortar lining by machine having following features:

    1. An applicator head which can be centered within pipe and which will centrifugally project mortar against wall of pipe at high velocity producing dense, uniformly distributed mortar on wall of pipe.

    2. Equipped with mechanically driven, rotating steel trowels that immediately follow applicator, providing smooth, hard surface without spiral shoulders. Compensate for torque so that machine will sit true in pipe and trowel faces will not vary in angle with mortar face during complete 360-degree 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.

    3. Design applicator so that nothing will 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.

4. 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.

5. 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 City Engineer accepts Work.

1.21 INSPECTION (EXCEPT MORTAR COATED PIPE)

1. Include cost of inspection described in Paragraph 3.08, Inspection, in contract unit price for water line. Furnish copies of certified inspection reports to City Engineer for review.

2. 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.

1.22 COATINGS AND LININGS INSPECTION RESPONSIBILITIES

1. Contractor is responsible for quality control of coatings and linings applications and testing and inspection stipulated in this Section. City Engineer 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 high-performance coatings at phases of coatings and linings, field- or shop-applied. Contractor is responsible for proper application and performance of coatings and linings whether or not City Engineer provides such inspection.

2. 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.

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

1. Areas less than or equal to 6 inches 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.

2. Areas greater than 6 inches 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 2 inch. 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 3 parts sand to 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 2 hour. 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 10 minutes.

    6. Apply cement mortar to repair area 2 inch 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 2 inch long wire gauge.

    7. Curing: Place plastic sheeting over repair area, use tape to adhere plastic to area surrounding repair area. Let cure for 4 days then remove plastic sheeting.

END OF SECTION