

## SECTION 02400 - STEEL PIPE, MORTAR LINED AND COATED

### PART 1 - GENERAL

#### 1.1 WORK INCLUDED IN THIS SECTION

- A. The WORK of this Section includes providing mortar-lined and mortar-coated steel pipe, including fittings and specials, complete in place.

#### 1.2 REFERENCE SPECIFICATIONS

- A. Except as otherwise indicated, the current editions of the following apply to the WORK of this Section.

1.	AWWA	C200	Steel Water Pipe 6 Inch and Larger
2.	AWWA	C205	Cement-Mortar Protective Lining and Coating for Steel Water Pipe-4 Inch and Larger-Shop Applied
3.	AWWA	C206	Field Welding for Steel Water Pipe Fittings
4.	AWWA	C207	Steel Pipe Flanges
5.	AWWA	C208	Dimensions for Fabricated Steel Water Pipe Fittings
6.	AWWA	C602	Cement-Mortar Lining of Water Pipelines 4-inch and Larger-In Place
7.	AWWA	M11	Steel Water Pipe - A Guide for Design and Installation

#### 1.3 SUBMITTALS

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

1. Shop drawings
  - a. Shop drawings showing dimensions and details of pipe, joint fittings, fitting specials, valves and appurtenances.
  - b. Joint and fitting wall construction details which indicate the type and thickness of cylinder; the position, type, size, and area of reinforcement; manufacturing tolerances; and all other pertinent information required for the manufacture of the product.
  - c. Joint details shall be submitted where deep bell or butt strap joints are required for control of temperature stresses.
  - d. Fittings and specials details such as elbows, reducers, wyes, tees, crosses, outlets, connections and test bulkheads, and nozzles or other specials where shown which indicate amount and position of all reinforcement. All fittings and specials shall be properly reinforced to withstand the internal pressure, both circumferential and longitudinal, and the external loading conditions as indicated in the Contract Documents.
  - e. Material lists and steel reinforcement schedules which include and describe all materials to be utilized.

- f. Full and complete information regarding location, type, size, and extent of all welds shall be shown on the shop drawings. The shop drawings shall distinguish between shop and field welds.
- g. Shop drawings shall indicate by welding symbols or sketches the details of the welded joints, and the preparation of parent metal required to make them.

2. Design Calculations

- a. Calculations supporting selected wall thickness.
- b. Calculations supporting welded joint design.

B. Certificates

- 1. The CONTRACTOR shall furnish a certification stating that all pipe, special fittings, and other products or materials furnished under this Section of the Specifications comply with AWWA C200 and C205.

C. Test Reports

- 1. The CONTRACTOR shall furnish certified reports of the following tests:
  - a. Physical and chemical properties of all steel.
  - b. Hydrostatic test reports.
  - c. Results of production weld tests.
  - d. Upon request by the DISTRICT, mill test reports on each sheet from which steel is rolled will be submitted.

1.4 INSPECTION

A. Factory Inspection

- 1. All pipe shall be subject to inspection at the place of manufacturer in accordance with the provisions of AWWA C200 and C205, respectively, as supplemented by the requirements herein.
- 2. The CONTRACTOR shall notify the DISTRICT in writing of the manufacturing starting date not less than 14 calendar days prior to the start of any phase of the pipe manufacture.

## 1.5 WELDING

- A. All welding procedures used to fabricate pipe shall be prequalified under the provisions of AWS D1.1.
- B. Welding procedures shall be required for, but not necessarily limited to, longitudinal and girth or spiral welds for pipe cylinders, spigot and bell ring attachments, reinforcing plates and ring flange welds, and plates for lug connections.
- C. All welding shall be done by skilled welders, welding operators, and tackers who have had adequate experience in the methods and materials to be used.
- D. Welders shall be qualified under the provisions of AWS D1.1 by an independent local, approved testing agency not more than 6 months prior to commencing work on the pipeline. Machines and electrodes similar to those used in the WORK shall be used in qualification tests.
- E. The CONTRACTOR shall furnish all material and bear the expense of qualifying welders.

## 1.6 TESTING

- A. Except as modified herein, all materials used in the manufacture of the pipe shall be tested in accordance with the requirements of AWWA C200 and C205, as applicable.
  - 1. Shop Testing of Steel Pipe
    - a. After the joint configuration is completed and prior to lining with cement-mortar, each length of pipe of each diameter and pressure class shall be shop-tested and certified to a pressure of at least 80 percent of the yield strength of the pipe steel.
    - b. Production weld tests shall be conducted in compliance with AWWA C200. In addition to the frequency of tests required in AWWA C200, weld tests shall be conducted on each 2,000 feet of production welds and at any other times there is a change in the welding procedure or welding equipment.
  - 2. Shop Testing of Steel Plate Special
    - a. Upon completion of welding, but before lining and coating, each special shall be bulkheaded and tested under a hydro-static pressure of not less than 1-1/2 times the design pressure; provided, that if straight pipe used in fabricating the specials has been previously tested and meets the requirements of the applicable piping Section, no further hydrostatic testing will be required; or provided, that all other welded seams are tested by the liquid penetrant inspection procedure conforming to ASTM E165, under Method "B" and "Leakage Testing" or where applicable by the soap and compressed air method at an air pressure of 25 psi. Any pin holes or porous welds which may be revealed by the test shall be chipped out and rewelded and the special retested.
    - b. No outside coating shall be applied over a seam prior to testing; however, mortar lining may be applied over a seam prior to hydrostatic testing, but under

such conditions said pressure test shall be held on the pipe or fitting for a period of not less than 30 minutes.

- B. The CONTRACTOR shall perform said material tests at no additional cost to the DISTRICT. The DISTRICT shall have the right to witness all testing conducted by the CONTRACTOR; provided, that the CONTRACTOR's schedule is not delayed for the convenience of the DISTRICT.
- C. In addition to those tests specifically required, the DISTRICT may request additional samples of any material including mixed concrete and lining and coating samples for testing by the DISTRICT. The additional samples shall be furnished at no additional cost to the DISTRICT.
- D. All expenses incurred in making samples for certification of tests shall be borne by the CONTRACTOR.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL**

- A. Mortar lined and coated steel pipe shall conform to AWWA C200 and C205, subject to the following supplemental requirements. The pipe shall be of the diameter and class shown, shall be furnished complete with rubber gaskets or welded joints, as indicated in the Contract Documents, and all specials and bends shall be provided as required for a complete piping system.
- B. Specials are defined as fittings, closure pieces, bends, reducers, wyes, tees, crosses, outlets, manifolds, and other steel plate specials, wherever located, and all piping above ground or in structures.
- C. Dimensions of fabricated steel pipe fittings shall comply with AWWA C208.
- D. Pipe 14 inches in diameter and larger, the inside diameter after lining shall not be less than the nominal diameter specified or shown.
- E. Pipe smaller than 14 inches in diameter may be furnished in standard outside diameters.
- F. The pipe lining shall have smooth dense interior surfaces and shall be free from fractures, excessive interior surface crazing and roughness.
- G. Closures and correction pieces shall be provided as required so that closures may be made due to different headings in the pipe laying operation and so that correction may be made to adjust the pipe laying to conform to pipe stationing shown on the Drawings.
- H. The CONTRACTOR shall be fully liable for the cost of replacement or repair of pipe and specials which are damaged.
- I. The CONTRACTOR shall legibly mark all pipes and specials in accordance with the laying schedule and marking diagram. Each pipe shall be numbered in sequence and said number shall appear on the laying schedule and marking diagram in its proper location for installation.

- J. All special pipe sections and fittings shall be marked at each end indicating the top. The word “top” shall be painted or marked on the outside top spigot end of each pipe section.

## 2.2 STRUTTING

- A. Adequate strutting shall be provided on all specials, fittings, and straight pipe so as to avoid damage to the pipe and fittings during handling, storage, hauling, and installation. In addition, the following requirements shall apply:
1. The strutting shall be placed as soon as practicable after the mortar lining has been applied and shall remain in place while the pipe is loaded, transported, unloaded, installed and backfilled at the jobsite.
  2. The strutting materials, size, and spacing shall be adequate to support the earth backfill plus any greater loads which may be imposed by the backfilling and compaction equipment.
  3. Any pipe damaged during handling, hauling, storage, or installation due to improper strutting shall be repaired or replaced.
  4. The details of the strutting assembly shall be submitted for review by the CONTRACTOR prior to the start of pipe manufacture.

## 2.3 PIPE DESIGN CRITERIA

### A. General

1. The pipe shall be steel pipe, mortar-lined and mortar-coated, with rubber gasketed or field welded joints as shown. The pipe shall consist of steel cylinder, either shop-lined or lined-in-place with portland cement-mortar with an exterior coating of cement mortar.
2. The pipe shall be designed, manufactured, tested, inspected, and marked according to applicable requirements of AWWA C200 except as hereinafter modified.
3. The pipe shall be of the diameter and indicated pressure class. The minimum steel cylinder thickness for each pipe size shall be as indicated.
4. Maximum pipe lengths for laying shall be 40 feet with shorter lengths provided as required.

### B. Cylinder Thickness for Internal Pressure

1. For resistance to internal pressure, the thickness of the steel cylinder shall not be less than the greater of that determined by the following formulas:

$$\text{a. } T = \frac{P_w D/2}{Y/S_t} \qquad \text{b. } T = \frac{P_t D/2}{Y/S_w}$$

Where: T = Steel cylinder thickness, inches  
D = Outside diameter of steel cylinder, inches

- $P_w$  = Design working pressure, psi
- $P_t$  = Design transient pressure, psi
- $Y$  = Specified minimum yield point of steel, psi
- $S_w$  = Safety factor of 2.0 at design working pressure
- $S_t$  = Safety factor of 1.5 at design transient pressure

D. Unless otherwise indicated,  $P_w$  shall be assumed to equal the indicated pipe pressure class and  $P_t$  shall be assumed to equal  $1.33 P_w$ . In no case shall the design stress ( $Y/S_w$ ) exceed 16,500 psi at design working pressure,  $P_w$ , nor shall the design stress ( $Y/S_t$ ) exceed 22,000 psi at design transient pressure,  $P_t$ , nor shall the steel shell thickness be less than No. 10 gauge (0.135 in.) or the nominal pipe diameter divided by 240, whichever is greater, as show in the following table:

<u>Nominal Pipe Diameter (in.)</u>	<u>Minimum Cylinder Thickness (in.)</u>
6 - 30	0.135
36	0.150
42	0.175
48	0.200
54	0.225

E. Upon determination of cylinder thickness, for internal pressure, deflection of the pipe shall be checked by the following formula:

$$\text{Defl}_x = \frac{DKW^3}{EI + 0.0614 E'r^3}$$

Where:  $\text{Defl}_x$  = Vertical deflection of pipe in inches, not to exceed 0.015 times the nominal diameter.

$D$  = Deflection lag factor (1.0-1.5)

$K$  = Bedding constant (0.1)

$W$  = Vertical load on pipe, lb/in (see Notes 1 and 2)

$r$  = Mean radius of pipe shell, inches

$EI$  = Pipe wall stiffness, lb-in (see Note 3)

$E'$  = Modulus of soil reaction, lb/in<sup>2</sup> (1100 for 90 percent Standard Proctor; 1500 for 95 percent Standard Proctor; 2500 for 100 percent Standard Proctor, i.e., cement crushed rock)

Note 1: In the determination of the vertical load on the pipe,  $W$ , the trench condition shall normally apply unless an actual embankment condition exists or the trench width exceeds the transition width, in which case the embankment condition shall apply. Yard piping shall always be designed for an embankment condition. The CONTRACTOR is cautioned that depth of covers less than 3 feet, if permitted, shall be investigated for concentrated wheel loads.

Note 2: For depths of cover of 10 feet or greater, the earth load shall be computed assuming the trench/embankment condition as applicable. For depths of cover of less than 10 feet, HS-20 live load shall be included. For depths of cover of 3 feet or less, HS-20 live load plus impact shall be included. The determination of live load and impact factors shall be as recommended by AASHTO in “Standard Specifications for Highway Bridges.”

Note 3: Value of EI is based on the sum of the pipe wall stiffness, mortar lining and coating, and steel cylinder, assuming that it acts as a three-part laminar ring which considers no bond between the steel cylinder and the applied lining and coating. The term “pipe wall stiffness” as used herein is defined as EI, where “E” is the modulus of elasticity (E=30,000,000 psi for steel and E=4,000,000 psi for mortar) and “I” is the transverse moment of inertia per unit length of pipe wall, the factors in the forgoing expression to be dimensionally compatible.

Trench Condition:

$$W_d = C_d w B_d^2$$

Where:  $W_d$  = Earth load, lb/ft

$C_d$  = Load coefficient

$K_u'$  = 0.13

$w$  = Unit weight of full, lb/cu ft 120 lb/ft<sup>3</sup>

$B_d$  = Trench width at top of pipe, feet

Positive Projecting Embankment Condition:

$$W_c = C_c w B_c^2$$

Where:  $W_c$  = Earth load, lb/ft

$C_c$  = Load coefficient

$K_u$  = 0.13

$w$  = Unit weight of full, lbs/cf 120 lb/ft<sup>3</sup>

$B_c$  = Trench width at top of pipe, feet

$r_{sd}$  = Settlement ratio

$P$  = Projection ratio

- F. If the calculated deflection,  $Defl_x$ , exceeds 0.015 times the nominal diameter, the composite pipe section shall be thickened or the quality of pipe zone backfill shall be improved to achieve a higher soil modulus.

## 2.4 DESIGN SPECIALS

- A. Except as otherwise provided herein, materials, fabrication and shop testing of straight pipe shall conform to the requirements of AWWA C200. Dimensions for fittings shall conform to AWWA C208. The minimum thickness of plate for pipe from which specials are to be fabricated shall be the greater of that determined by the following two formulas:

$$a. \quad T = \frac{P_w D}{2 Y S_w} \qquad b. \quad T = \frac{P_t D}{2 Y S_t}$$

- Where:
- T = Steel cylinder thickness, inches
  - D = Outside diameter of steel cylinder, inches
  - $P_w$  = Design working pressure, psi
  - $P_t$  = Design transient pressure, psi
  - Y = Specified minimum yield point of steel, psi
  - $S_w$  = Safety factor of 2.0 at design working pressure
  - $S_t$  = Safety factor of 1.5 at design transient pressure

- B. In no case shall the design stress at design working pressure ( $Y/S_w$ ) for mortar-coated steel pipe exceed 16,500 psi or 22,000 psi at design transient pressure ( $Y/S_t$ ), nor shall plate thickness be less than the thickness of adjacent mainline pipe or the following:

<u>Nominal Pipe Diameter (in.)</u>	<u>Pipe Manifolds Piping Above Ground Piping in Structures</u>	<u>Elbows Bends Reducers</u>
24 and under	3/16 - inch	10 - ga.
25 to 48	1/4 - inch	1/4 - inch
over 48	5/16 - inch	5/16 - inch

- C. Pipe installed on saddle supports shall be designed to limit the longitudinal bending stress to a maximum of 10,000 psi. Design shall be in accordance with the provisions of Chapter 7 of AWWA M-11.

## 2.5 MATERIALS

- A. Pipe manufactured under AWWA C200 shall be fabricated from sheet conforming to the requirements of Table 1 in Section 2. All longitudinal and girth seams, whether straight or spiral, shall be butt welded using an approved electric-fusion-weld process.

- B. All steel used for the fabrication of pipe shall have a maximum carbon content of 0.25 percent, a maximum sulfur content of 0.015 percent, and shall have a minimum elongation of 22 percent in a 2-inch gauge length.
- C. All steel used in fabricating pipe which exceeds 1/2-inch in thickness shall be tested for notch toughness using the Charpy V-Notch test in accordance with ASTM A370. The steel shall withstand a minimum impact of 25 ft. lb. at a temperature of 30 degrees F.
- D. Steel shall be fine-grained, fully kilned and manufactured by the continuous casting process.
- E. Cement for mortar shall conform to the requirements of AWWA C205; provided that cement for mortar lining shall be Type II and mortar lining shall be Type II. Fly ash or pozzolan shall not be used as a cement replacement.

## 2.4 JOINT DESIGN

### A. GENERAL

1. The standard field joint for steel pipe shall be either a single-welded lap joint or a rubber-gasketed joint for all pipe sizes up to and including 54-inch diameter and shall be single-welded lap joint for pipe sizes above 60-inch diameter. Double welded joints with air taps for air pressure testing shall be provided where shown.
2. Mechanically coupled, or flanged joints shall be required where shown.
3. Butt-strap joints shall be used only where required for closures or where shown, or approved by the DISTRICT.
4. The joints furnished shall have the same or higher pressure rating as the abutting pipe.
5. Shop-applied interior linings and exterior coatings shall be held back from the ends of the pipe as indicated or as otherwise acceptable to the DISTRICT.
6. Where indicated, restrained joints shall be field-welded joints. Designs shall include considerations of stresses induced in the steel cylinder, the joint rings, and any field welds, caused by thrust at bulkheads, bends, reducers, and line valves resulting from the design working pressure. All joints to be field welded for thrust restraint shall have the joint rings attached to the cylinder with double fillet welds. Calculations for the number of joints that need to be welded on each side of all vertical and horizontal angle points shall be furnished to the DISTRICT at no additional cost to the DISTRICT.
7. For field welded joints, design stresses shall not exceed 50 percent of the indicated minimum yield strength of the grade of steel utilized, or 16,500 psi, whichever is less, for the part being examined when longitudinal thrust is assumed to be uniformly distributed around the circumference of the joint. At the CONTRACTOR's option, the steel cylinder area may be progressively reduced from the point of maximum thrust to the end of the restrained length.

B. Lap Joints

1. Preparation for field welding shall be in accordance with AWWA C200.
2. The method used to form, shape and size bell ends shall be such that the physical properties of the steel are not substantially altered. Unless otherwise approved by the DISTRICT, bell ends shall be formed by an expanding press or by being moved axially over a die in such a manner as to stretch the steel plate beyond its elastic limit to form a truly round bell of suitable diameter and shape. No process will be permitted in which the bell is formed by rolling. Faying surfaces of the bell shall be essentially parallel, but in no case shall the bell slope vary more than 2 degrees from the longitudinal axis of the pipe.

C. Bell and Spigot Ends

1. The CONTRACTOR shall require the pipe manufacturer to submit details complete with significant dimensions and tolerances and also to submit performance data indicating that the proposed joint has performed satisfactorily under similar conditions. In the absence of a history of field performance, the results of a test program shall be submitted.
2. The method used to form, shape and size bell ends shall be such that the physical properties of the steel are not substantially altered.
3. Unless otherwise approved by the DISTRICT, bell ends shall be formed by an expanding press or by being moved axially over a die in such a manner as to stretch the steel plate beyond its elastic limit to form a truly round bell of suitable diameter and shape. No process will be permitted in which the bell is formed by rolling.
4. Unless otherwise approved by the DISTRICT, spigot ends with rolled gasket grooves shall be non-destructively tested by the dye penetrant or magnetic particle method for the full circumference, especially at the weld seam area.
5. Faying surfaces of the bell and spigot shall be essentially parallel, but in no case shall the bell slope vary more than 2 degrees from the longitudinal axis of the pipe.
6. Actual yield strength of the steel used in the spigot rolling operation (i.e. yield strength values in mill certifications and subsequent destructive test results) shall be limited to 50,000 psi.
7. For bell-and-spigot ends with rubber gaskets, the clearance between the bells and spigots shall be such that when combined with the gasket groove configuration and the gasket itself, will provide watertight joints under all operating conditions when properly installed.
8. Full and complete information regarding location, type, size, and extent of all welds shall be shown on the shop drawings. The shop drawings shall distinguish between shop and field welds. Shop drawings shall indicate by welding symbols or sketches the details of the welded joints, and the preparation of parent metal required to make them. Joints or groups of joints in which welding sequence or technique are especially important shall be carefully controlled to minimize shrinkage stresses and distortion.

D. Flanges

1. AWWA C207, Class D flanges (matching ANSI/ASME B16.1, Class 125 flanges for bolt hole size and drilling) shall be used for pressures up to 150 psi.
2. AWWA C207, Class E flanges (matching ANSI/ASME B16.1, Class 125 flanges for bolt hole size and drilling) shall be used for pressures between 150 psi and 250 psi.
3. AWWA C207, Class F flanges (matching ANSI/ASME B16.1, Class 250 flanges for bolt hole size and drilling) shall be used for pressures between 250 psi and 300 psi or when Class 250 butterfly valves or other appurtenances using flanges corresponding to AWWA C207 Class F are required.
4. Flanges shall be flat-faced type only. Segmented flanges shall not be used.

2.7 CEMENT-MORTAR LINING OF PIPE

A. General

1. Except as otherwise required, interior surfaces of all steel pipe, fittings, and specials shall be cleaned and lined in the shop with cement-mortar lining applied centrifugally in conformity with AWWA C205.
  2. The progress of the application of mortar lining shall be regulated in order that all hand work, including the repair of defective areas is cured in accordance with the provisions of AWWA C205.
  3. During the lining operation and thereafter, the pipe shall be maintained in a round condition by suitable bracing or strutting.
  4. The lining machine shall be of a type that has been used successfully for similar work.
  5. If lining is damaged or found faulty at delivery site, the damaged or unsatisfactory portions shall be replaced with lining conforming to these Specifications at no additional cost to the DISTRICT.
- B. The minimum lining thickness shall be in accordance with AWWA C200, Table 1 of Section 4.
- C. The pipe shall be left bare where field joints occur as indicated. Ends of the linings shall be left square and uniform. Feathered or uneven edges will not be permitted.
- D. Defective linings, as determined by the DISTRICT, shall be removed from the pipe wall and shall be replaced to the full thickness required. Defective linings shall be cut back to a square shoulder in order to avoid feathered edged joints.
- E. Cement-mortar for patching shall be the same materials as the mortar for machine lining, except that a finer grading of sand and mortar richer in cement shall be used when field inspection indicates that such mix will improve the finished lining of the pipe.

F. For all pipe and fittings with plant-applied cement-mortar linings, the pipe manufacturer shall provide a polyethylene or other suitable bulkhead on the ends of the pipe and on all special openings to prevent drying out of the lining. All bulkheads shall be substantial enough to remain intact during shipping and storage until the pipe is installed.

G. Cement-Mortar Lining for Field Application

1. The materials and design of in-place cement-mortar lining shall be in accordance with AWWA C602 and the following supplementary requirements.
  - a. Portland cement shall conform to Type II, ASTM C150.
  - b. Pozzolanic material shall not be used in the mortar mix.
  - c. Admixtures shall contain no calcium chloride.
  - d. The minimum lining thickness shall be as indicated for shop-applied cement-mortar lining and the finished inside diameter after lining shall be as shown.

2.8 CEMENT MORTAR COATING OF PIPE

- A. The exterior surfaces of pipe which will be exposed to the atmosphere inside structures or above ground shall be thoroughly cleaned and then given a shop coat of rust-inhibitive primer and a finish coat conforming to the requirements of Section 04000.
- B. All pipe for buried service, including bumped heads, shall be coated with a 1-inch minimum thickness of reinforced cement-mortar coating.
  1. Exterior surfaces of pipe or fittings passing through structure walls shall be cement-mortar coated six (6) inches beyond the inside wall face.
  2. Unless otherwise specified, the reinforcement for the coating of pipe sections may be spiral wire, wire fabric, or wire mesh in accordance with AWWA C205.
  3. The welded wire fabric shall be securely fastened to the pipe with welded clips or strips of steel.
  4. The wire spaced 2 inches on centers shall extend circumferentially around the pipe. The ends of reinforcement strips shall be lapped 4 inches and the free ends tied or looped to assure continuity of the reinforcement.

2.9 FABRICATION OF SPECIALS

A. General

1. Specials and fittings shall conform to dimensions stipulated in AWWA C208.
2. Reinforcement for wyes, tees, outlets, and nozzles shall be designed in accordance with AWWA Manual M-11. Reinforcement shall be designed for the pressure indicated and shall be in accordance with the Standard Details.

3. Specials and fittings shall be equal in pressure design strength and shall have the same lining and coating as the adjoining pipe.
  4. Unless otherwise specified, the minimum radius of elbows shall be 2.5 times the pipe diameter and the maximum miter angle on each section of the elbow shall not exceed 11-1/4 degrees.
- B. Fittings may be fabricated from pipe that has been mechanically lined or coated.
- C. Access manholes with covers shall be as indicated. All threaded outlets shall be forged steel suitable for 3000 psi service.
- D. Outlets 12-inch and smaller may be fabricated from Schedule 30 or heavier steel pipe in the standard outside diameters, i.e. 12-3/4 inch, 10-3/4 inch, 8-5/8 inch, 6-5/8 inch, and 4-1/2 inch.
- E. The design of outlet reinforcement shall be in accordance with the procedures given in Chapter 12 of AWWA Manual M-11, except that the design pressure, P, used in the M-11 procedure shall equal the greater of  $1.25 P_w$  or  $0.9376 P_t$ . Unless otherwise indicated, outlets 2 inches in diameter and smaller need not be reinforced.
- F. In lieu of saddle or wrapper reinforcement as required by the design procedure in Manual M-11, pipe or specials with outlets may be fabricated in their entirety of steel plate having a thickness equal to the sum of the pipe wall plus the required reinforcement.
- G. Where required by the M-11 design procedure crotch plate reinforcement shall be furnished.
- H. Steel welding fittings shall conform to ASTM A234.
- I. Ends for Mechanical-Type Couplings
1. Except as otherwise required, where mechanical-type couplings are indicated, the ends of pipe shall be banded with Type C collared ends using double fillet welds. Where pipe 12-inch and smaller is furnished in standard schedule thicknesses, and where the wall thickness equals or exceeds the coupling manufacturer's minimum wall thickness, the pipe ends may be grooved.
- J. Lining
1. All requirements pertaining to thickness, application and curing of lining indicated for straight pipe shall apply to specials, with the following proviso. If the special cannot be lined centrifugally, it shall be lined by hand. In such case, the lining shall be reinforced with 2-inch by 4-inch No. 12 welded wire fabric positioned approximately in the center of the lining. The wires spaced 2-inches on center shall extend circumferentially around the pipe with the fabric securely fastened to the pipe. Splices shall be lapped 4 inches and the free ends tied or looped to assure continuity.

- K. Coating
  - 1. All requirements pertaining to thickness, application and curing of coating for straight pipe shall apply to specials. Pipe above ground or in structures shall be field painted as required in Section 04000.
- L. Specials and fittings that cannot be mechanically lined and coated shall be lined and coated by hand-application, using the same materials as are used for the pipe and in accordance with the applicable AWWA C602 Standards. Coating and lining applied in this manner shall provide protection equal to that indicated for the pipe.
- M. Areas of lining that have been damaged by such fabrication shall be repaired by hand-applications in accordance with applicable AWWA C602 Standards.

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION OF PIPE**

- A. Immediately before placing each section of pipe in final position for jointing, the bedding for the pipe shall be checked for firmness and uniformity of surface to support the pipe for its full length.
- B. When the pipe is being laid, it shall be turned and placed where possible, so that any slightly damaged portion will be on top. The damaged area shall be repaired for the protection of any exposed steel.
- C. All damaged areas along the pipe shall be repaired using materials and methods acceptable to the DISTRICT.
- D. Moderate deflections and long radius curves may be made by means of beveled joint rings, by pulling standard joints, by using short lengths of pipe, or a combination of these methods; provided that pulled joints shall not be used in combination with bevels.
- E. The maximum total allowable angle for beveled joints shall be 5 degrees per pipe joint.
- F. The maximum allowable angle for pulled joints shall be in accordance with the manufacturer's recommendations or the angle which results from a 3/4 inch pull out from normal joint closure, whichever is less.
- G. All horizontal deflections or fabricated angles shall fall on the alignment. [In congested city streets or at other locations where underground obstructions may be encountered, the chord produced by deflecting the pipe shall be no further than 6 inches from the alignment indicated.]
- H. All vertical deflections shall fall on the alignment and at locations adjacent to underground obstructions, points of minimum earth cover, and pipeline outlets and structures. The pipe angle points shall match the angle points indicated.

- I. For pipe wall thicknesses of 3/8-inch or less, the maximum radial offset (misalignment) for submerged arc and gas metal arc welded pipe shall be 0.1875 times the wall thickness or 1/16-inch, whichever is larger.
- J. For pipe wall thickness greater than 3/8-inch, the maximum radial offset shall be 0.1875 times the wall thickness or 5/32-inch, whichever is smaller.
- K. Bevels shall be provided on the bell ends.
- L. Mitering of the spigot ends will not be permitted.
- M. For pipe 24 inches in diameter and larger, pipe struts shall be left in place until backfilling operations have been completed.
- N. Struts in pipe smaller than 24 inches may be removed immediately after laying, provided that the deflection of the pipe during and after backfilling does not exceed that indicated. After the backfill has been placed, the struts shall be removed and shall remain property of the CONTRACTOR.
- O. The openings of all pipe and specials where the pipe and specials have been cement-mortar lined in the shop shall be protected with suitable bulkheads to maintain a moist atmosphere and to prevent unauthorized access by persons, animals, water or any undesirable substance. The bulkheads shall be so designed to prevent drying out of the interior of the pipe. The CONTRACTOR shall introduce water into the pipe to keep the mortar moist where moisture has been lost due to damaged bulkheads.

### 3.2 RUBBER GASKETED JOINTS

- A. Immediately before jointing pipe, the spigot end of the pipe shall be thoroughly cleaned, and a clean rubber gasket lubricated with a NSF approved vegetable-based lubricant shall be placed in the spigot groove.
- B. The volume of the gasket shall be "equalized" by moving a metal rod between the gasket and the spigot ring around the full circumference of the spigot ring.
- C. The bell of the pipe already in place shall be carefully cleaned and lubricated with a NSF approved vegetable-based lubricant. The spigot of the pipe section shall then be inserted into the bell of the previously laid joint and telescoped into its proper position.
- D. Tilting of the pipe to insert the spigot into the bell will not be permitted.
- E. After the pipe units have been joined, a feeler gauge shall be inserted into the recess and moved around the periphery of the joint to detect any irregularity in the position of the rubber gasket. If the gasket cannot be "felt" all around, the joint shall be disassembled. If the gasket is undamaged, as determined by the DISTRICT, it may be reused, but only after the bell ring and gasket have been relubricated.

### 3.3 WELDED JOINTS

- A. General
  - 1. Field welded joints shall be in accordance with AWWA C206.

2. Where exterior welds are performed, adequate space shall be provided for welding and inspection of the joints.
3. During installation of welded steel pipe in either straight alignment or on curves, the pipe shall be laid so that the lap joint clearance, at any point around the circumference of the joint, shall comply with the requirements of AWWA C206.
4. Unless double fillet welds are indicated, field welded lap joints may, at the CONTRACTOR's option, be made on either the inside or the outside of the pipe.
5. Butt straps, where used or required, shall be a minimum of 6 inches wide, the same thickness as the pipe wall and shall provide for a minimum of 3/4 inch lap at each pipe joint.
6. The pipe ends shall be cut straight on joints where butt straps are used for realignment, adjustment, or deflection, and fillet welds shall be made as indicated.
7. After the pipe and pipe joint are properly positioned in the trench, the length of pipe between joints shall be backfilled to at least 1 foot above the top of the pipe. Care shall be exercised during the initial backfilling to prevent movement of the pipe and to prevent any backfill material from being deposited on the joint.
8. Prior to the beginning of the welding procedure, any tack welds used to position the pipe during laying shall be removed. Any annular space between the faying surfaces of the bell and spigot shall be equally distributed around the circumference of the joint by shimming, jacking, or other suitable means. The weld shall then be made in accordance with AWWA C206. Where more than one pass is required, each pass except the first and final one shall be peened to relieve shrinkage stresses; and all dirt, slag, and flux shall be removed before the succeeding bead is applied.
9. As soon as practicable after welding of each joint, all field-welded joints shall be tested by the liquid penetrant inspection procedure conforming to the requirements of ASTM E165 under Method "B" and "Leak Testing." All defects shall be chipped out, rewelded and retested.
10. Following tests of the joint, the exterior joint spaces shall be coated in accordance with these specifications after which backfilling may be completed.

### 3.4 JOINT COATING AND LINING

- A. The interior and exterior joint recesses shall be thoroughly wiped clean and all water, loose scale, dirt and other foreign material shall be removed from the inside surface of the pipe.
- B. The cement for joint grout and mortar shall be portland cement acceptable under ASTM C150 and shall be of the same type used for the pipe coating.
- C. After the pipe has been laid and after sufficient backfill has been placed between the joints to hold the pipe securely in place, the outside annular space between pipe sections shall be completely filled with grout formed by the use of polyethylene foam-lined fabric bands.

- D. The grout shall be composed of one part cement to not more than 2 parts sand, thoroughly mixed with water to a consistency of thick cream.
- E. The grout space prior to filling shall be flushed with water so that the surface of the joint to be in contact with the grout will be thoroughly moistened when the grout is poured.
- F. The joint shall be filled with grout by pouring from one side only, and shall be rodded with a wire or other flexible rod or vibrated so that the grout completely fills the joint recess by moving down one side of the pipe, around the bottom of the pipe and up the opposite side. Pouring and rodding the grout shall be continued to allow completion of the filling of the entire joint recess in one operation.
- G. Grouting of the outside joint spaces shall be kept as close behind the laying of the pipe as possible except that in no case shall grouting be closer than 3 joints of the pipe being laid.
- H. Grout Bands (Diapers)
  - 1. The grout bands or heavy-duty diapers shall be polyethylene foam-lined fabric with steel strapping of sufficient strength to hold the fresh mortar, resist rodding of the mortar and allow excess water to escape.
  - 2. The foam plastic shall be 100 percent closed cell, chemically inert, insoluble in water and resistant to acids, alkali and solvents.
  - 3. The fabric backing shall be cut and sewn into 9-inch wide strips with slots for the steel strapping on the outer edges.
  - 4. The polyethylene foam shall be cut into strips 6 inches wide and slit to a thickness of 1/4-inch which will expose a hollow or open cell surface on one side.
  - 5. The foam liner shall be attached to the fabric backing with the open or hollow cells facing toward the pipe.
  - 6. The foam strip shall cover the full interior circumference of the grout band with sufficient length to permit an 8-inch overlap of the foam at or near the top of the pipe joint.
  - 7. Splices to provide continuity of the material will be permitted.
  - 8. The polyethylene foam material shall be protected from direct sunlight.
- I. The polyethylene foam-lined grout band shall be centered over the joint space with approximately equal widths extending over each pipe end and securely attached to the pipe with steel straps. After filling the exterior joint space with cement grout, the flaps shall be closed and overlapped in a manner that fully encloses the grout with polyethylene foam. The grout band shall remain in position on the pipe joint.

J. Joint Lining

1. After the backfill has been completed to final grade, the interior joint recess shall be filled with mortar of stiff consistency mixed in proportions of one part cement to 2 parts sand.
2. The mortar shall be tightly packed into the joint recess and troweled flush with the interior surface, and all excess shall be removed.
3. At no point shall there be an indentation or projection of the mortar exceeding 1/16-inch.
4. For pipe smaller than 24 inches in diameter, before the spigot is inserted into the bell, the bell shall be daubed with mortar containing one part cement to 2 parts sand. The spigot end then shall be forced to the bottom of the bell and excess mortar on the inside of the joint shall be swabbed out.

K. The lining machine shall be of a type that has been used successfully for a similar size of pipe. No ball ("rabbit") shall be used. These joints shall be video taped by the CONTRACTOR or hand holes shall be provided at each joint, all at no additional cost to the DISTRICT.

L. The CONTRACTOR shall perform all work in a thorough and workmanlike manner by trained personnel, under the supervision of experienced personnel skilled in machine application of cement-mortar lining to pipelines of size comparable to this work.

M. Curing of the in-place cement-mortar lining shall be in accordance with AWWA C602.

N. The CONTRACTOR shall provide additional protective devices as required to ensure that the airtight covers, which maintain a moist condition in the pipeline, are not damaged.

O. Defective areas encompassing the full diameter of the pipe shall be replaced by machine wherever the length measured along the pipe centerline is greater than 5 feet; otherwise defective areas may be replaced by hand.

END OF SECTION