

American Water Works Association
ANSI/AWWA C205-89
(Revision of ANSI/AWWA C205-85)



AWWA STANDARD
FOR
**CEMENT-MORTAR PROTECTIVE LINING AND
COATING FOR STEEL WATER PIPE—
4 IN. AND LARGER—SHOP APPLIED**



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AMERICAN WATER WORKS ASSOCIATION

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Foreword

This foreword is for information only and is not a part of AWWA C205.

I. History of Standard. The first edition of this standard, designated 7A.7-41, Standard Specifications for Cement-Mortar Protective Coating for Steel Water Pipe of Sizes 30 Inches and Over, was approved by the AWWA Board of Directors June 26, 1941. Before that a tentative draft had been published in the January 1940 *Journal AWWA* for review and comment.

The first edition provided for the field application of cement-mortar lining, which was deleted by action of the Board of Directors effective June 30, 1951. Pending the promulgation of AWWA C602, Cement-Mortar Lining of Water Pipelines—4 In. (100 mm) and Larger—In Place, the ninth, tenth, and eleventh printing of 7A.7 (AWWA C205) continued to carry the withdrawn section.

The next edition, published in 1962, was a major revision and provided for pipe sizes of 4 in. and larger. The standard was subsequently revised in 1980 and 1985.

II. Discussion. Cement-mortar, lined-and-coated steel pipe was first used in the United States in the late 1800s. Some of the first pipelines were in service for almost a century. However, it was not until the 1920s that a practical method of plant-applied, cement-mortar lining was developed. The first plant-applied linings were installed by standing the pipe on end, placing a tapered plug with a rope attached to the leading end inside the pipe, placing enough cement mortar on top of the plug to coat the pipe, and then pulling the plug up through the pipe. Improvements in the lining process were developed, and the centrifugal process for plant-applied, cement-mortar lining emerged.

Cement-mortar-lined and cement-mortar-coated steel pipe combines the physical strength of steel with the protective qualities of cement mortar. The lining, applied centrifugally, creates a smooth, dense finish that protects the pipe from tuberculation and provides a measure of corrosion protection. The smooth interior surface provides a high flow coefficient, which is maintained for a long period of time. In addition, the cement-mortar coating results in a tough, durable, and rugged coating that forms an alkaline environment where oxidation or corrosion of the steel is inhibited.

The purchaser is cautioned that soft, aggressive waters, as well as prolonged contact with heavily chlorinated water, may be injurious to cement-mortar linings. When this environment is anticipated, further studies may be necessary to determine the suitability of this type of lining.

III. Information Regarding Use of This Standard. When purchasing protective cement-mortar lining or coating for steel water pipe under the provisions of this standard, the purchaser shall furnish supplementary specifications, including specific details where applicable, regarding the following:

1. Standard used—that is, AWWA C205-89, Standard for Cement-Mortar Protective Lining and Coating for Steel Water Pipe—4 In. and Larger—Shop Applied.

2. Whether interior lining only, exterior coating only, or both lining and coating are required.

3. Footage, inside diameter after lining, lengths of pipe sections, steel-wall thickness, type of joint, and information regarding fittings.

4. Whether an affidavit of compliance is required (Sec. 1.7).

5. Type of wire-fabric reinforcement required, if limited to a single type (Sec. 2.1.2).

6. Type of cement required, if other than type I or type II (Sec. 2.2).

7. Lining—options or restrictions, if any, such as thickness of lining (Sec. 4.2), thickness tolerances (Sec. 4.2), and length of lining holdback (Sec. 4.2).

8. Coating—options or restrictions, if any, such as type of undercoat, if any (Sec. 5.1); length of coating holdback (Sec. 5.3); thickness of mortar coating (Sec. 5.3); thickness tolerances (Sec. 5.3); type of reinforcement (Sec. 5.5.1); and method of curing (Sec. 5.9.1).

IV. Major Revisions. Major changes to the 1985 standard made in this revision are summarized in the following list:

1. Adding ribbon-mesh reinforcement for pipe coating and lining of specials.
2. Adding requirements for minimum compressive strength and appropriate testing, for cement-mortar lining.
3. Permitting membrane curing of cement-mortar lining, under certain conditions.

V. Metric Conversions. Metric conversions of all dimensions and physical requirements have been included in this standard. Metric dimensions are direct conversions of US customary units and are not those specified in International Standard Organization (ISO) standards.

American Water Works Association



ANSI/AWWA C205-89
(Revision of ANSI/AWWA C205-85)

AWWA STANDARD FOR

CEMENT-MORTAR PROTECTIVE

LINING AND COATING FOR STEEL

WATER PIPE—4 IN. AND

LARGER—SHOP APPLIED

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard covers the material, application, and curing of shop-applied, cement-mortar protective linings and coatings for steel water pipe.

1. The inside of all pipe shall receive a cement-mortar lining applied by centrifugally spinning or by a method known to provide equivalent results.

2. Miters, angles, bends, reducers, and other specials shall be lined with mortar by hand troweling, mechanical placement, pneumatic placement, or a method known to provide equivalent results.

3. The outside of pipe and specials, when specified, shall receive a reinforced cement-mortar coating applied by mechanical placement, pneumatic placement, or a method known to provide equivalent results.

1.1.1 *Field application.* For field application of cement-mortar lining, refer to AWWA C602, Standard for Cement-Mortar Lining of Water Pipelines—4 In. (100 mm) and Larger—In Place.

Sec. 1.2 Definitions

The following definitions shall apply in this standard:

1.2.1 *Accelerated curing*: The process of maintaining a constantly moist surface by creating a humid atmosphere at an elevated temperature.

1.2.2 *Autogenous healing*: The process by which cracks in concrete or cement mortar are healed by the formation of calcium carbonate in the presence of moisture.

1.2.3 *Contractor*: The party that enters into a contract or agreement with the purchaser to furnish the work and materials in accordance with the provisions of this standard.

1.2.4 *Mechanical placement*: The process of applying mortar by projecting the mortar at a high velocity against the surface or by any mechanically operated compaction system.

1.2.5 *Pneumatic placement*: The process of applying mortar by propelling the mortar against any surface using compressed air or steam.

1.2.6 *Purchaser*: The party entering into a contract or agreement for the purchase of any materials or work to be performed in accordance with the provisions of this standard. A purchaser may or may not be the owner.

1.2.7 *Spinning*: The process of applying mortar to the inside surfaces of pipe in which the mortar introduced into the pipe is spread on the surface of the pipe and compacted thereon by the centrifugal force resulting from spinning the pipe about its longitudinal axis until the mortar has consolidated sufficiently to allow removal of the pipe from the equipment.

Sec. 1.3 References

This standard references the following documents. In their latest editions, the references form a part of this standard to the extent specified herein. In any case of conflict, the requirements of this standard shall prevail.

AWWA C602—Standard for Cement-Mortar Lining of Water Pipelines—4 In. (100 mm) and Larger—In Place.

ASTM* A82—Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.

ASTM A185—Standard Specification for Steel Welded Wire, Fabric, Plain, for Concrete Reinforcement.

ASTM A497—Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement.

ASTM C31—Standard Practice for Making and Curing Concrete Test Specimens in the Field.

ASTM C33—Standard Specification for Concrete Aggregates.

ASTM C35—Standard Specification for Inorganic Aggregates for Use in Gypsum Plaster.

ASTM C39—Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

ASTM C150—Standard Specification for Portland Cement.

ASTM C172—Standard Method of Sampling Freshly Mixed Concrete.

*American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM C309—Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.

Sec. 1.4 Inspection

All materials furnished and work done shall be subject to inspection. The contractor shall furnish, without additional cost to the purchaser, reasonable assistance for the inspection of materials and workmanship. The engineer or inspector shall, at all times, have access to all parts of the shop and works where such material is being manufactured or such work is being performed.

Sec. 1.5 Materials and Workmanship

Materials furnished shall meet the provisions of this standard. Work or material that fails to conform to this standard may be rejected at any time before final acceptance thereof.

Sec. 1.6 Equipment

The equipment for applying cement mortar and for carrying and transporting lined, coated, or lined-and-coated pipe shall permit the workers to follow the procedure and obtain results required by this standard.

Sec. 1.7 Affidavit of Compliance

The purchaser may require that the contractor furnish an affidavit that all materials and work furnished under the purchaser's order will comply or have complied with the applicable requirements of this standard.

SECTION 2: MATERIAL

Sec. 2.1 Reinforcement

2.1.1 *Spiral-wire reinforcement for pipe coating.* Steel wire shall be a minimum size of W0.5 (0.080 in.). The wire shall conform to the requirements of ASTM A82. Reinforcing wire need not be galvanized unless otherwise specified by the purchaser.

2.1.2 *Wire-fabric reinforcement for pipe coating and for lining of specials.* Reinforcement shall be 2 × 4 W0.5 × W0.5 welded wire fabric. The wire shall conform to the requirements of ASTM A185 or ASTM A497. Unless otherwise specified by the purchaser, wire-fabric reinforcement may be either crimped or uncrimped.

2.1.3 *Ribbon-mesh reinforcement for pipe coating and for lining of specials.* Ribbon mesh shall be 1-in. × 1-in. (25-mm × 25-mm) mesh of 18-gauge wire or 1 1/2-in. × 1 1/2-in. (38-mm × 38-mm) mesh of 17-gauge wire. The wire shall conform to the requirements of ASTM A82. Mesh shall not be crimped.

Sec. 2.2 Portland Cement

Portland cement shall conform to the requirements of ASTM C150 for type I or type II cement, or as otherwise specified by the purchaser.

Sec. 2.3 Sand

Sand shall consist of inert materials having hard, strong, durable, uncoated grains conforming to the requirements of ASTM C33.

Sec. 2.4 Mixing Water

Water shall be clean, colorless, and free from injurious quantities of organic matter, alkali, salt, or other impurities that might reduce the strength, durability, or other desirable qualities of the mortar.

Sec. 2.5 Curing Compound

Curing compound for curing cement-mortar linings and coatings shall comply with ASTM C309.

Sec. 2.6 Paint

The paint or other materials used to prevent the rusting of steel surfaces at holdbacks of mortar lining or coating before pipe installation shall be a quick-drying, corrosion-resistant material with good bonding properties to steel and shall dry tack-free and smooth within 4 h after application. The paint shall be applied, without sags or runs, to a thickness that will not impair the clearances required for proper installation of the joint. The paint material applied to the interior of pipe or fittings shall be free from contaminants that may be harmful to the end user of the potable water.

SECTION 3: SURFACE PREPARATION

Sec. 3.1 Cleaning Surfaces

All surfaces to be mortar lined or mortar coated shall be cleaned to remove loose or other foreign matter that could interfere with the adherence of the cement mortar.

SECTION 4: MORTAR LINING

Sec. 4.1 Cement Mortar

Cement mortar shall be composed of cement, sand, and water, well mixed and of proper consistency to obtain a dense, homogeneous lining that will adhere firmly to the pipe surface. If an admixture is to be used by the contractor, it shall be subject to review and acceptance by the purchaser. Proportions of sand to cement shall be not more than 3 parts sand to 1 part cement, by weight. The soluble chloride-ion (Cl⁻) content of the cement-mortar mix shall not exceed 0.15 percent, expressed as a percentage of cement weight.

Sec. 4.2 Thickness

Cement-mortar lining shall be uniform in thickness, except at joints or other discontinuities in the pipe wall. Lining thickness shall be as listed in Table 1 or as specified by the purchaser. Ends of lining shall be left square and uniform with regard to the longitudinal axis of the pipe, and the lining holdback shall be as specified by the purchaser for the type of joint required.

Table 1 Cement-Mortar Lining Thickness

| Nominal Pipe Size | | Lining Thickness | | Tolerance | |
|-------------------|--------------------|------------------|------|-------------|--------------|
| in. | (mm) | in. | (mm) | in. | (mm) |
| 4-10 | (100-250) | 1/4 | (6) | -1/16 + 1/8 | (-1.6 + 3.2) |
| 11-23 | (280-580) | 5/16 | (8) | -1/16 + 1/8 | (-1.6 + 3.2) |
| 24-36 | (600-900) | 3/8 | (10) | -1/16 + 1/8 | (-1.6 + 3.2) |
| greater than 36 | (greater than 900) | 1/2 | (13) | -1/16 + 1/8 | (-1.6 + 3.2) |

Sec. 4.3 Equipment

4.3.1 *Lining.* Straight sections of pipe shall be lined by use of a spinning machine specifically designed and built for the purpose of rotating the pipe section and centrifugally applying cement-mortar linings to the interior of steel pipe or by a method known to provide equivalent results.

4.3.2 *Mixing.* The mortar shall be mixed in batches. The amount of cement and sand entering into each batch shall be measured by weight. The quantity of water entering the mixer shall be measured automatically by an adjustable device, or it shall be otherwise measured to ensure that the correct quantity of water is being added.

Sec. 4.4 Machine Lining

4.4.1 *Bracing.* When required to prevent distortion or vibration during the spinning, each section of pipe shall be suitably braced with external or internal supports appropriate to the equipment.

4.4.2 *Placement.* In application of lining by a spinning machine, the entire quantity of mortar required for completion of the lining of the section of pipe shall be placed without interruption.

4.4.3 *Finish.* After the mortar has been distributed to a uniform thickness, the rotation speed shall be increased to produce a dense mortar with a smooth surface.

4.4.4 *Surplus water.* Provision shall be made for removal of surplus water by air blowing, tilting of the pipe, or other methods approved by the purchaser.

Sec. 4.5 Lining of Specials

4.5.1 *General.* The application of cement-mortar lining to miters, angles, bends, reducers, and other special sections, the shape of which precludes application by the spinning process, shall be accomplished by mechanical placement, pneumatic placement, or hand application and finished to produce a smooth, dense surface.

4.5.2 *Reinforcement.* Wire-fabric reinforcement or ribbon-mesh reinforcement shall be applied to the interior of fittings larger than 24 in. (610 mm) and shall be secured at frequent intervals by tack welding to the pipe, by clips, or by wire. The wires on 2-in. (50-mm) spacing on the 2-in. × 4-in. (50-mm × 100-mm) fabric shall extend circumferentially around the fitting. Repaired areas of machine-applied linings at miters, pipe ends, outlets, and other cuts made in the lining for fabrication of the fitting need not be reinforced if the width of the repair area does not exceed 12 in. (300 mm). Repairs for widths exceeding 6 in. (150 mm) shall be bonded to the steel and adjacent faces of the lining with a bonding agent.

4.5.3 *Thickness.* Thickness shall be as required for spun lining of straight sections, except that it may be varied by feathering or filleting to a smooth transition with adjoining sections of pipe.

4.5.4 *Handwork.* Cement mortar for handwork shall be of the same materials and in the same sand-cement proportions as the mortar for machine lining except that plaster sand conforming to ASTM C35 may be used in place of sand conforming to ASTM C33. Areas shall be cleaned to remove loose or other foreign matter that would interfere with the adherence of the cement mortar and, if necessary, shall be moistened with water just before the placing of the mortar.

Sec. 4.6 Defective Lining

4.6.1 *General.* All defects, including but not restricted to sand pockets, voids, oversanded areas, blisters, and cracking as a result of impacts, shall be cut out and replaced by hand or pneumatic placement to the same thickness as required for the mortar lining.

4.6.2 *Lining cracks.* Temperature and shrinkage cracks in the mortar lining less than $1/16$ in. (1.6 mm) in width need not be repaired. Cracks wider than $1/16$ in. (1.6 mm) need not be repaired if it can be demonstrated to the satisfaction of the purchaser that the cracks will heal autogenously under continuous soaking in water. The autogenous healing process may be demonstrated by any procedure that keeps the lining of the pipe continually wet or moist. Pipe used in the demonstration shall be representative of the pipe to be supplied, and water for the moistening of the pipe shall be chemically similar to the water to be carried in the pipeline.

Sec. 4.7 Curing of Lining

4.7.1 *General.* Immediately after completion of spinning, the pipe sections may be moved to a curing area. Care shall be exercised at all times to prevent damage to the lining. At the option of the contractor, linings shall be accelerated cured or moist cured. Accelerated curing or moist curing may be used interchangeably on a time-ratio basis of $5\ 1/3$ h of moist curing to 1 h of accelerated curing, except that moist curing may be used only if the minimum ambient temperature exceeds 40°F (5°C) continuously during the required minimum curing period. In any case, linings shall be kept continually moist until the completion of the minimum specified curing period.

4.7.2 *Moist curing.* On arrival at the curing area, but not later than 30 min after completion of the lining operation, pipe ends shall be covered with plastic or wet burlap for a minimum period of 24 h before applying the exterior coating, if such coating is specified. No credit shall be allowed for any time during which the temperature drops below 50°F (10°C). If a cement-mortar exterior coating is not specified, the lining shall be kept moist for four days before shipment. In either case, the lining shall be cured for a total period of four days before shipment. The ends of the pipe sections shall be kept closed during the curing period, with plastic end caps except when sprinkling heads are used, the reinforcement and outside coatings are being applied, or accelerated curing is being substituted. If the plastic end caps are installed at that time, they can be used for shipping to the jobsite as indicated in Sec. 6.2.1. The contractor shall exercise care and diligence to avoid drying out or cracking of the lining.

4.7.3 *Accelerated curing.* Accelerated curing may begin immediately on arrival of the pipe at the curing area, but the temperature of the pipe shall not exceed 90°F (32°C) for 3 h or until the mortar has taken its initial set, whichever occurs first.

The ambient vapor shall then be maintained at a temperature between 110°F and 150°F (43°C and 66°C) at a relative humidity of not less than 85 percent for a minimum curing period of 6 h, after which the exterior coating may be applied, if such coating is specified. If cement-mortar coating is not specified, the lining shall be cured for 18 h before shipment. In either case, the lining shall be cured for a total period of 18 h before shipment.

4.7.4 *Alternative curing methods.* When allowed by the purchaser, alternative curing methods may be substituted providing the method used by the contractor produces a cured lining equivalent to that set forth in Sec. 4.7.2 and Sec. 4.7.3.

Sec. 4.8 Mortar Lining Test Cylinders

4.8.1 *Mortar test cylinders.* A set of at least two standard test cylinders, 6 in. (150 mm) in diameter by 12 in. (300 mm) in length, shall be made each day from the mortar lining for each shift to satisfy the 7-day and 28-day strength quality control requirements of Sec. 4.8.4. The mortar shall be removed from the mix in accordance with ASTM C172 or samples may be prepared by omitting sufficient water from the production mix to obtain a 1-in. to 3-in. (25-mm to 75-mm) slump. Test cylinders shall be made in conformance with ASTM C31. The test cylinders shall be cured with the pipe at the same temperature and for the same total length of time. Other sized cylinders, such as 2 in. × 4 in. (50 mm × 100 mm), may be used to test compressive strength. If the 7-day test attains 28-day test requirements, then the 28-day test need not be completed (Sec. 4.8.4).

4.8.2 *Centrifugal test cylinders.* Centrifugally spun test cylinders may be substituted for mortar test cylinders, at the option of the contractor. Test cylinders shall be spun about their longitudinal axes in 6-in. (150-mm) diameter by 12-in. (300-mm) long steel molds at a speed that will simulate the compaction of mortar in the lining to produce a spun-cylinder wall thickness of at least 1 1/2 in. (38 mm). The net cross-sectional area of the hollow cylinder shall be used to determine its compressive strength. Damaged cylinders shall not be tested.

4.8.3 *Test cylinders.* All test cylinders shall be tested in accordance with ASTM C39 by an approved testing laboratory unless the contractor has approved testing facilities at the work site. In such an event, the tests shall be made by the contractor. All cylinder tests shall be made at the expense of the contractor. Certified test reports will be submitted by the contractor if required by the contract documents of the purchaser. Tests ordered by the purchaser in addition to those required in Sec. 4.8.1 shall be at the expense of the purchaser. Retests are the contractor's responsibility.

4.8.4 *Strength of mortar lining.* Mortar test cylinders shall attain a minimum compressive strength of 2600 psi (18 MPa) in 7 days and 4500 psi (31 MPa) in 28 days. Pipe made with mortar lining that does not meet the strength requirements set forth herein shall be subject to rejection.

The average of any 10 consecutive strength tests of cylinders representing each mortar mix shall be equal to or greater than the specified strength, and not more than 20 percent of the strength tests shall have values less than the specified strength. No cylinder test result shall be less than 80 percent of the specified strength.

SECTION 5: MORTAR COATING

Sec. 5.1 General

When specified, the external protection of steel pipe shall be a reinforced cement-mortar coating applied over the outer surfaces of the pipe sections and specials. If the pipe has been mortar lined, the curing times specified in Sec. 4.7 must elapse before the coating is applied. When a dielectric undercoat is specified by the purchaser, curing temperature of the mortar coating shall not exceed the maximum allowable for dielectric material exposure.

Sec. 5.2 Cement Mortar

Cement mortar applied by mechanical placement or by the steam-pneumatic process shall consist of not more than 3 parts sand to 1 part cement, by weight. The water in the mixture shall be carefully controlled so that the mortar will not run, sag, or segregate.

Cement mortar applied by the air-pneumatic process (gunite) shall consist of not more than 3 parts sand to 1 part cement, by weight. The water in the mixture shall be carefully controlled so that the mortar will not run, sag, or segregate.

The soluble chloride-ion (Cl^-) content of the cement-mortar mix shall not exceed 0.15 percent, expressed as a percentage of cement weight.

Sec. 5.3 Thickness

Cement-mortar coating shall be uniform in thickness except at joints or other discontinuities in the pipe. Coatings shall be $\frac{3}{4}$ -in. (19-mm) minimum thickness for all sizes of pipe unless otherwise specified by the purchaser. Ends of coatings shall be uniform and square to the longitudinal axis of the pipe, and the coating holdback shall be as specified by the purchaser for the type of joint required.

Sec. 5.4 Equipment

Straight and special sections of the pipe shall be coated with cement mortar applied by pneumatic, mechanical, steam, or other placement methods known to provide equivalent results.

Sec. 5.5 Reinforcement

5.5.1 General. Unless otherwise specified by the purchaser, the reinforcement for the coating of pipe sections may be spiral wire, wire fabric, or wire mesh (ribbon mesh) in accordance with the provisions of Sec. 2.1. Reinforcement shall be free of oil, grease, and other contaminants that might reduce the adherence between the coating and reinforcement. Reinforcement with surface oxidation may be used, provided that the surface is not pitted. All reinforcement shall be placed in the middle third of the coating. When cement-mortar coating is applied over a dielectric undercoat, the reinforcement shall not be attached to or otherwise be in contact with the steel pipe.

5.5.2 Spiral wire. Attachment of ends and splices in the wire shall be by welding or other suitable means acceptable to the purchaser. The wire reinforcing may be applied under moderate tension while the mortar coating is being applied. Maximum spacing of the wires shall be 1 $\frac{1}{2}$ in. (38 mm).

5.5.3 Wire fabric. Splices shall be made by welding or other suitable means acceptable to the purchaser. Circular and longitudinal joints shall be lapped a dis-

tance of at least one mesh. The wires on 2-in. (50-mm) spacing on the 2-in. × 4-in. (50-mm × 100-mm) fabric shall extend circumferentially around the pipe.

5.5.4 *Wire mesh.* Attachment of ends and splices in the wire shall be by a means approved by the purchaser. When 1-in. × 1-in. (25-mm × 25-mm), 18-gauge wire mesh is used, the spiral lap shall be 1 in. (25 mm) and the spliced lap 3 in. (76 mm). When 1 1/2-in. × 1 1/2-in. (38-mm × 38-mm), 17-gauge mesh is used, the spiral lap shall be 1 1/2 in. (38 mm) and the spliced lap 4 1/2 in. (114 mm).

Sec. 5.6 Application of Mortar Coating

5.6.1 *Application.* Mortar coating shall be applied by mechanical or pneumatic placement to the specified thickness in one or more continuous application(s). Allowance shall be made for splices of reinforcing wire. If applied in more than one course, the interval between the first and last course shall be not more than 2 h. The mortar shall be projected at high velocity against the exterior surfaces of the pipe or shall be applied by an equivalent method to produce a hard, tight-adhering coating of the specified thickness.

5.6.2 *Support.* If required, the pipe shall be adequately braced with interior struts or rings to prevent damage during handling and coating and, if mortar lined, to protect the lining.

5.6.3 *Interrupted placement.* If it is necessary to defer placing the coating of any portion of a pipe length, then the interruption joint shall be a square shoulder. Before placing fresh material against the joint, the contact surfaces shall be carefully cleaned and wetted to obtain adherence between the fresh material and that previously placed. Care shall also be taken not to shatter or damage the material previously placed or disturb the imbedded reinforcement.

When reinforcement of the spiral-wire type is used, the end of the wire at the edges of the portion to be left uncoated shall be attached to the pipe shell by welding or by other suitable means. When applied over a dielectric undercoat, the anchorage method shall be subject to review and acceptance by the purchaser.

Sec. 5.7 Coating of Specials

5.7.1 *Reinforcement.* Mortar coating for pipe bends and other special sections not adapted to the application of spiral-wire coating reinforcement shall be reinforced with wire fabric or ribbon mesh. The fabric or ribbon mesh shall be as specified in Sec. 2.1.2 or Sec. 2.1.3, shall be applied over the surface of the pipe to be coated, and may be held away from the pipe shell with self-furring mesh, furring clips, or an equivalent method. Ends of circumferential strips of reinforcing shall be overlapped as specified in Sec. 5.5.3 or Sec. 5.5.4. Where dielectric undercoating is used, the anchorage method shall be subject to review and acceptance by the purchaser.

5.7.2 *Application.* The application shall conform to Sec. 5.6.1, with the exception that hand application may be substituted for mechanical or pneumatic placement.

5.7.3 *Thickness.* Thickness shall be as required for straight sections, but may be varied by feathering or filleting to form a smooth transition with adjoining sections.

Sec. 5.8 Defective Coating

5.8.1 *Sand pockets and porous spots.* If any sand pockets or porous spots occur, they shall be completely cut out and replaced by pneumatic placement or

hand application of mortar in the proportion of 2 1/2 parts sand to 1 part cement, by weight.

5.8.2 *Coating cracks.* Care shall be exercised to minimize the occurrence of cracks in the mortar coating. However, hairline cracks need not be repaired. The need for the repair of wider cracks must be determined by the purchaser after evaluation of the pipeline environment and, if required by the purchaser, such cracks shall be repaired by the contractor at no additional cost to the purchaser. Repair procedures shall include the brushing or wiping of neat cement into the cracks, autogenous healing of the cracks by additional moist curing, the painting of the cracks with an epoxy coating, or a combination of these methods.

NOTE: Repair procedures involving extensive chipping or routing of the cracks should be avoided as this procedure tends to deepen and lengthen the existing cracks and may damage the bond or adhesion between the coating and the cylinder.

Sec. 5.9 Curing of Coating

5.9.1 *General.* After the initial set has taken place, the mortar coating shall be cured by the moist or accelerated curing methods or, unless otherwise specified by the purchaser, a membrane material may be applied immediately following the coating application. Moist and accelerated curing may be used interchangeably on a time-ratio basis of 5 1/3 h of moist curing to 1 h of accelerated curing, except curing temperatures shall not exceed the maximum allowable for dielectric undercoat material.

5.9.2 *Moist curing.* Moist curing shall begin as soon as the pipe or special can be sprinkled with water without damage to the coating. The coating shall be kept continually moist by intermittent or continuous spraying for a period of at least four days. Moist curing may be used only if the minimum ambient temperature exceeds 40°F (5°C) continuously during the minimum required curing period, and no credit shall be allowed for any time during which the temperature drops below 50°F (10°C).

5.9.3 *Accelerated curing.* Accelerated curing of the pipe or special may begin immediately after completion of the coating operation or within 6 h thereafter. The temperature of the pipe or special shall not exceed 90°F (32°C) until the cement-mortar coating has taken its initial set or until a period of 3 h has elapsed, whichever occurs first. The relative humidity shall be not less than 85 percent at a temperature between 110°F and 150°F (42°C and 64°C) for at least 18 h.

5.9.4 *Membrane curing.* Membrane curing shall consist of the complete encapsulation of the coating by application of a material that will retain the moisture of the applied cement-mortar coating.

SECTION 6: HANDLING

Sec. 6.1 Manufacture

During the entire period of the application of the lining and coating and the curing thereof, the section shall be carefully supported and handled to avoid damage to the mortar. If a pipe section must be moved, such operation shall be done with every reasonable precaution to protect against damage. Any damaged portion of the lining or coating shall be cut out and replaced.

Sec. 6.2 Delivery

Care shall be exercised during loading, hauling, and unloading to prevent damage to any of the components of the completed pipe. Pipe and specials shall be suitably braced, supported to provide sufficient bearing area to prevent damage to the coating, and tied to prevent shifting or distortion of the pipe during transportation.

6.2.1 *Plastic end caps.* Plastic end caps shall be securely fastened to pipe ends of completed pipe for protection of the cement-mortar lining. End caps shall be maintained in place until time of installation.

APPENDIX A

Field Joints

This appendix is for information only and is not a part of AWWA C205.

SECTION A.1: GENERAL

This appendix covers material requirements and application procedures recommended for the application of cement-mortar field joints.

SECTION A.2: INSIDE JOINTS

Sec. A.2.1 Material

Cement mortar used for the joints shall be composed of a minimum of 1 part cement to not more than 2 parts sand, by weight, dry mixed, and moistened with sufficient water to permit packing and troweling without crumbling. Sand shall be graded within the limits for plaster sand conforming to ASTM C35. Water shall be clean and free from injurious quantities of organic matter, alkali, salts, and other impurities. If permitted by the purchaser, workability of the mortar may be improved by replacing not more than 7 percent, by weight, of the cement with hydrated lime, or by replacing not more than 20 percent, by weight, of the cement with pozzolan.

Sec. A.2.2 Application

Inside joints of mortar-lined pipe shall be filled with cement mortar and finished off smooth and flush with the inside surface of the pipe by troweling or by equivalent means. Before placing the joint mortar material against the surfaces of the lining, the surfaces shall be carefully cleaned, have all soap removed, and then be wetted to ensure a good bond between the lining and the joint mortar. The pipeline shall not be put into service until the mortar has cured for a minimum of 24 h.

A.2.2.1 For pipe diameters 22 in. (560 mm) and larger. When pipe is 22 in. (560 mm) in diameter and larger, the joints shall be finished smooth with the inside surface of the lining by troweling.

A.2.2.2 For pipe diameters less than 22 in. (560 mm). When the pipe is smaller than 22 in. (560 mm), the joint shall be finished by placing a sufficient amount of the joint mortar in the bell end of the section against the shoulder of the lining, just before installing it in the line. When the section has been laid in place, the joint shall be finished by pulling a rubber ball or the equivalent through the joint to finish it off smooth with the inside surface of the lining.

SECTION A.3: OUTSIDE JOINTS

Sec. A.3.1 Material

Grout shall be composed of 1 part cement to not more than 2 parts sand, by weight, thoroughly mixed with water to the consistency of thick cream. Sand gradulation shall conform to the requirements of ASTM C33, except that 100 percent shall pass a No. 16 sieve.

Sec. A.3.2 Application

Outside field joints shall be coated with cement mortar, retained by suitable bands or diapers to bridge the joint and retain the grout without leakage. Before filling, the grout space shall be flushed with water so that the surface of the joint to be in contact with the grout will be moistened when the grout is poured. The joint shall be filled with grout by pouring from one side only until the grout reaches at least the pipe spring line on the opposite side, 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. Care shall be taken to leave no unfilled space. The exposed portion of the grout at the top of the pipe shall be coated with a sealing compound or covered with burlap or moist earth.