American Water Works Association
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ANSI/AWWA C220-17
(Revision of ANSI/AWWA C220-12)

AWWA Standard

Stainless-Steel Pipe, ½ In. (13 mm) and Larger

Effective date: Nov. 1, 2017.
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AWWA Standard

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Contents

All AWWA standards follow the general format indicated subsequently. Some variations from this format may be found in a particular standard.

Foreword

This foreword is for information only and is not a part of ANSI/AWWA C220.*

I. Introduction.

I.A. *Background.* Stainless steel is a standard material used to construct pipe. It offers low corrosion rates, which makes it suitable for the handling of potable water while maintaining water purity and quality. In 1996, stainless steel was approved as a material suitable to meet the NSF†/ANSI 61, Drinking Water Treatment Components—Health Effects, Addendum C, requirement.

I.B. *History.* In 1987, the AWWA Standards Council directed the Standards Committee on Steel Pipe to develop a standard for stainless-steel pipe used in water treatment or conveying facilities. The first edition of ANSI/AWWA C220, Standard for Stainless-Steel Pipe, 4 in. (100 mm) and Larger, was approved by the AWWA Board of Directors on June 18, 1992. The second edition was approved Jan. 25, 1998. The third edition was approved on Jan. 16, 2005. The fourth edition was approved on Jan. 22, 2012. This fifth edition was approved on June 11, 2017.

I.C. *Acceptance.* In May 1985, the US Environmental Protection Agency (USEPA) entered into a cooperative agreement with a consortium led by NSF International (NSF) to develop voluntary third-party consensus standards and a certification program for direct and indirect drinking water additives. Other members of the original consortium included the Water Research Foundation (formerly AwwaRF) and the Conference of State Health and Environmental Managers (COSHEM). The American Water Works Association (AWWA) and the Association of State Drinking Water Administrators (ASDWA) joined later.

In the United States,‡ authority to regulate products for use in, or contact with, drinking water rests with individual states. Local agencies may choose to impose requirements more stringent than those required by the state. To evaluate the health effects of products and drinking water additives from such products, state and local agencies may use various references, including

1. Specific policies of the state or local agency.

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* American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.
† NSF International, 789 North Dixboro Road, Ann Arbor, MI 48113.
‡ Persons outside the United States should contact the appropriate authority having jurisdiction.

2. Two standards developed under the direction of NSF: NSF/ANSI 60, Drinking Water Treatment Chemicals—Health Effects, and NSF/ANSI 61, Drinking Water System Components—Health Effects.

3. Other references, including AWWA standards, *Food Chemical Codex*, *Water Chemicals Codex*,* and other standards considered appropriate by the state or local agency.

Various certification organizations may be involved in certifying products in accordance with NSF/ANSI 61. Individual states or local agencies have authority to accept or accredit certification organizations within their jurisdictions. Accreditation of certification organizations may vary from jurisdiction to jurisdiction.

Annex A, "Toxicology Review and Evaluation Procedures," to NSF/ANSI 61 does not stipulate a maximum allowable level (MAL) of a contaminant for substances not regulated by a USEPA final maximum contaminant level (MCL). The MALs of an unspecified list of "unregulated contaminants" are based on toxicity testing guidelines (noncarcinogens) and risk characterization methodology (carcinogens). Use of Annex A procedures may not always be identical, depending on the certifier.

ANSI/AWWA C220 does not address additives requirements. Users of this standard should consult the appropriate state or local agency having jurisdiction in order to

1. Determine additives requirements, including applicable standards.

2. Determine the status of certifications by parties offering to certify products for contact with, or treatment of, drinking water.

3. Determine current information on product certification.

II. Special Issues.

II.A. *Basis of Design.* ANSI/AWWA C220 pertains to the manufacture and testing of the stainless-steel pipe cylinder. ANSI/AWWA C220 includes all types and classes of stainless-steel pipe, ½ in. (13 mm) in diameter and larger, typically used in the water industry, regardless of pipe-manufacturing source.

The wall thickness of stainless-steel pipe is determined by (1) internal pressures; (2) external pressure; (3) special physical loading, such as continuous-beam loading with saddle supports or ring girders, vacuum conditions, type of joint used, and variations in operating temperature; and (4) practical considerations for handling, shipping, or similar operations.

* Both publications available from National Academy of Sciences, 500 Fifth Street, NW, Washington, DC 20418.

The design techniques described in AWWA Manual M11, *Steel Pipe—A Guide for Design and Installation*, are used to determine the minimum wall thicknesses of steel pipe. Pipe-wall thickness to meet the design requirements will be determined by the appropriate formulas in AWWA Manual M11 using stainless-steel material properties. The purchaser shall establish and specify the minimum wall thickness determined to be satisfactory for the service conditions of the pipe. Alternatively, the purchaser may provide the performance criteria for the pipeline and request the manufacturer to design the pipe for purchaser acceptance. The purchaser should consider the properties of the lining and coating materials, if specified, when selecting design stresses and deflection limits. The manufacturer may select materials and manufacturing processes within the limitations of this standard to produce pipe of the minimum wall thickness as specified or approved by the purchaser.

II.A.1 Application. The provisions of this standard cover the requirements for stainless-steel pipe for use in water treatment plants, water transmission and distribution systems, and other water facilities. The purchaser is responsible for determining whether any unusual circumstances related to the project require additional provisions that are not included in the standard. Such special conditions might affect design, manufacture, quality control, corrosion protection, or handling requirements.

II.A.2 Testing of Special Sections. Sec. 5.2.2.1 describes nondestructive testing methods for weld seams of special sections that may be necessary by request of the purchaser. The requirement for this special testing should be specified at the time of purchase.

II.A.3 Roundness of Pipe. The roundness of pipe during handling, shipping, joint makeup, and backfilling should be specified by the purchaser. Pipe may have to be stulled to remain round.

III. Use of This Standard. It is the responsibility of the user of an AWWA standard to determine that the products described in that standard are suitable for use in the particular application being considered.

III.A. *Purchaser Options and Alternatives.* The following information should be provided by the purchaser:

1. Standard used—that is, AWWA C220, Stainless-Steel Pipe, ½ in. (13 mm) and Larger, of latest revision.

2. Whether compliance with NSF/ANSI 61, Drinking Water System Components—Health Effects, is required.

3. A description and/or drawings detailing the total quantity of pipe required for each diameter.

4. Internal design pressure and other service conditions, if the manufacturer is required to design the pipe.

5. Design stress in the pipe wall at specified internal design pressure (as a percentage of minimum yield strength of the stainless steel), if the manufacturer is required to design the pipe.

6. Details of other federal, state or provincial, and local requirements (Sec. 4.2.1).

7. Specification of pipe standard and stainless-steel grade, if there is a preference (Sec. 4.2.2).

8. Drawings and calculations to be furnished by the manufacturer (Sec. 4.3.1 and Sec. 4.3.2), if the manufacturer is required to design the pipe.

9. Protective lining and coating, if required (Sec. 4.3.3).

10. Welding requirements (Sec. 4.4.2 and 4.4.3).

11. Qualification code for welding operators, if different from Sec. 4.4.3.4.1.

12. Length of pipe sections; random or specified lengths (Sec. 4.5.4).

13. Type of pipe ends; description or drawings (Sec. 4.6).

14. Drawing of butt straps and instructions as to whether or not butt straps are to be supplied separately or attached to the pipe (Sec. 4.6.5).

15. Requirements for cleaning and descaling (Sec. 4.8).

16. Special sections, indicating for each component part the dimensions or standard designation (Sec. 4.9.1) and the grade of material required (Sec. 4.9.2).

17. Type of flange, pressure rating, class, and inside diameter (ID) (Sec. 4.9.2.1).

18. Instructions regarding inspection at the place of manufacture (Sec. 5.l).

19. Minimum hydrostatic test pressure, if required and different from Sec. 5.2.1.

20. Method of nondestructive testing to be used for special sections (Sec. 5.2.2.1) or, in the case of severe service conditions, the requirements for hydrostatic testing of special sections (Sec. 5.2.2.2).

21. Requirements of marking, line diagrams, or laying schedules (Sec. 6.1).

22. Special handling and capping requirements (Sec. 6.2).

23. Affidavit of compliance, if required (Sec. 6.3).

III.B. *Modification to Standard.* Any modification of the provisions, definitions, or terminology in this standard must be provided by the purchaser.

IV. Major Revisions. Major revisions made to this standard in this edition include the following:

1. In the foreword, the third paragraph of Sec. II.A, Basis of Design, was updated to remove redundancies.

2. Sec. II.A.2 was slightly revised to remove the specific defining conditions.

3. Definitions for the terms *Butt Strap* and *Out-of-Roundness* were added in Section 3.

4. Sec. 4.3.3, Protective Lining and Coating, was revised to reflect industry practice.

5. Sec. 4.4.2, Fabrication of Pipe, was revised for clarity.

6. A sentence was added to Sec. 4.6.2, Ends for Mechanically Coupled Field Joints, addressing plain-end preparation.

7. In Sec. 5.2.1.1, Hydrostatic Test, a minimum time requirement for test pressure was added.

8. A requirement was added to Sec. 5.2.2.2, Hydrostatic Testing, for the required pressure to be maintained not less than 30 seconds.

9. In Sec. 6.2.3, Finished Pipe at Delivery Destination, a sentence regarding photos and other documentation was added.

V. Comments. If you have any comments or questions about this standard, please call AWWA Engineering and Technical Services at 303.794.7711, FAX at 303.795.7603; write to the department at 6666 West Quincy Avenue, Denver, CO 80235-3098; or email at standards@awwa.org.

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ANSI/AWWA C220-17
(Revision of ANSI/AWWA C220-12)

AWWA Standard

Stainless-Steel Pipe, ½ In. (13 mm) and Larger

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard pertains to stainless-steel pipe that is seamless, longitudinal-seam, or spiral-seam welded; ½ in. (13 mm) in nominal diameter and larger; and intended for the transmission and distribution of potable water, wastewater, and reclaimed water, and for use in other water-supply system facilities.

Sec. 1.2 Purpose

The purpose of this standard is to provide the minimum requirements for stainless-steel pipe, ½ in. (13 mm) and larger, including materials and quality of work, fabrication of pipe, specials and fittings, testing and inspection, and marking requirements.

Sec. 1.3 Application

This standard can be referenced in documents for purchasing and receiving, as well as serving as a guide for manufacturing, stainless-steel pipe, ½ in. (13 mm) and larger. The stipulations of this standard apply when this document has been referenced and then only to stainless-steel pipe, ½ in. (13 mm) and larger.

SECTION 2: REFERENCES

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

ANSI/AWWA C219—Bolted, Sleeve-Type Couplings for Plain-End Pipe.

ANSI/AWWA C226—Stainless-Steel Fittings for Waterworks Service, Sizes ½ in. Through 72 in. (13 mm Through 1,800 mm).

ANSI/AWWA C227—Bolted, Split-Sleeve Restrained and Nonrestrained Couplings for Plain-End Pipe.

ANSI/AWWA C228—Stainless-Steel Pipe Flange Joints for Water Service—Sizes 2 in. Through 72 in. (50 mm Through 1,800 mm).

ANSI/AWWA C606—Grooved and Shouldered Joints.

ASME*—Boiler and Pressure Vessel Code (BPVC), Sec. II, Part A; Sec. VIII; Sec. IX, Appendix 8.

ASTM† A240/A240M—Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

ASTM A312/A312M—Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.

ASTM A358/A358M—Standard Specification for Electric-Fusion-Welded Austenitic Chromium-Nickel Stainless Steel Pipe for High-Temperature Service and General Applications.

ASTM A380/A380M—Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.

ASTM A409/A409M—Standard Specification for Welded Large Diameter Austenitic Steel Pipe for Corrosive or High-Temperature Service.

ASTM A480/A480M—Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.

ASTM A778/A778M—Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.

ASTM A790/A790M—Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe.

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* ASME International, 3 Park Avenue, New York, NY 10016.
† ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428.

ASTM A928/A928M—Standard Specification for Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded With Addition of Filler Metal.

ASTM A999/A999M—Standard Specification for General Requirements for Alloy and Stainless Steel Pipe.

ASTM E340—Standard Test Method for Macroetching Metals and Alloys.

ASTM E426—Standard Practice for Electromagnetic (Eddy Current) Examination of Seamless and Welded Tubular Products, Titanium, Austenitic Stainless Steel and Similar Alloys.

AWWA Manual M11, *Steel Pipe—A Guide for Design and Installation*.

AWS* A3.0M/A3.0—Standard Welding Terms and Definitions; Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying.

AWS D1.6/D1.6M—Structural Welding Code—Stainless Steel.

AWS QC1—Standard for AWS Certification of Welding Inspectors.

MSS† SP-119—Factory-Made Wrought Belled End Pipe Fittings for Socket-Welding.

UNS (Unified Numbering System)—As per ASTM A240/A240M, Table 1, "Chemical Composition Requirements, Percent Designation Established in Accordance With Practice E 527 and SAE J 1086."

SECTION 3: DEFINITIONS

The following definitions shall apply in this standard:

1. *Bevel:* The angle formed between the prepared edge of a pipe end and a plane perpendicular to the longitudinal axis of the pipe. Bevels are generally used for butt joint welding of pipe ends.
2. *Butt joint:* A joint between two members aligned in the same plane.
3. *Butt strap:* A plate that overlaps and fastens two pieces butted together.
4. *Check analysis:* The chemical analysis taken from the coil, plate, or pipe.
5. *CJP:* Complete joint penetration.
6. *Constructor:* The party that furnishes the work and materials for placement or installation.

* American Welding Society, 550 Northwest LeJeune Road, Miami, FL 33126.

† Manufacturers Standardization Society of the Valve and Fittings Industry Inc., 127 Park St., NE, Vienna, VA 22180.

7. *Coupon (weld coupon):* A piece of stainless steel from which weld test specimens are cut.

8. *Fillet weld:* A weld of approximately triangular cross section, the throat of which lies in a plane disposed approximately 45 degrees from the surface of the parts joined. The size of the weld is expressed in terms of the width, in inches (millimeters), of one of its adjacent fused legs—the shorter leg if legs are unequal.

9. *Girth weld:* A circumferential weld lying in one plane, used to join sections into lengths of straight pipe or to join pieces of mitered pipe to form fabricated special sections and fittings.

10. *Longitudinal weld:* A weld parallel to the axis of the pipe.

11. *Manufacturer:* The party that manufactures, fabricates, or produces materials or products.

12. *Nominal diameter:* The commercial designation or dimension by which pipe is designated for standardization.

13. *Nominal wall thickness:* The thickness designation, as distinguished from the actual or measured thickness.

14. *Nominal weight per unit length:* The theoretical weight per unit length, calculated from the nominal wall thickness, as distinguished from the actual or measured weight per unit length.

15. *Out-of-roundness:* Amount by which a pipe has an imperfectly or unbalanced circular form.

16. *Passivation:* A process used to create a chemically inactive surface.

17. *Pickling:* A chemical process for removing contaminants and oxides from the pipe surface.

18. *Plain-end pipe:* Pipe not threaded, belled, or otherwise given a special end configuration.

19. *Potable water:* Water that is safe and satisfactory for drinking and cooking.

20. *Purchaser:* The person, company, or organization that purchases any materials or work to be performed.

21. *Reclaimed water:* Wastewater that becomes suitable for beneficial use as a result of treatment.

22. *Root:* That portion of a joint to be welded where the members approach closest to each other. In cross section, the root of a joint may be a point, a line, or an area.

23. *Seamless pipe:* Pipe without welds, made from solid ingots, blooms, billets, or round bars that have been hot pierced and brought to the desired size by extrusion and cold drawing to size.

24. *Special section:* Any piece of pipe other than a normal full-length straight section. This includes but is not limited to elbows, manhole sections, short pieces, reducers, adapter sections with special ends, and other nonstandard sections.

25. *Spiral-seam welded pipe:* Pipe in which the line of the seam forms a helix on the barrel of the pipe.

26. *Stainless steel:* Ferrous metals having chromium contents of at least 12 percent.

27. *Straight-seam welded pipe:* Pipe in which the line of the seam is parallel to the axis of the pipe.

28. *Supplier:* The party that supplies materials or services. A supplier may or may not be the manufacturer.

29. *UNS:* Unified Numbering System—an alloy designation system widely accepted in North America.

30. *Wastewater:* A combination of the liquid and water-carried waste from residences, commercial buildings, industrial plants, and institutions, together with any groundwater, surface water, and stormwater that may be present.

31. *Working pressure:* The maximum pressure under which a system or a zone within the system operates normally or in a static condition, whichever is greater.

SECTION 4: REQUIREMENTS

Sec. 4.1 Permeation

The selection of materials is critical for potable water, wastewater, and reclaimed water service and distribution piping in locations where there is likelihood the pipe will be exposed to significant concentrations of pollutants composed of low-molecular-weight petroleum products or organic solvents or their vapors. Documented research has shown that pipe materials (such as polyethylene and polyvinyl chloride) and elastomers, such as those used in jointing gaskets and packing glands, are subject to permeation by low-molecular-weight organic solvents or petroleum products. If a potable water, wastewater, or reclaimed water pipe must pass through such a contaminated area or an area subject to contamination,

consult with the manufacturer regarding permeation of pipe walls, jointing materials, and so on *before* selecting materials for use in that area.

Sec. 4.2 Materials

4.2.1 *General.* Materials shall comply with the requirements of the Safe Drinking Water Act and other federal regulations for potable water, wastewater, or reclaimed water systems as applicable.

4.2.2 *Pipe made to ASTM requirements.* Pipe manufactured to meet the requirements of one or more of the ASTM specifications listed in Sec. 4.4.1 shall use stainless-steel materials as listed in Table 1. The materials shall meet the requirements of ASTM A240/A240M.

4.2.3 *Fabricated pipe.* Pipe is to be fabricated to meet the requirements of Sec. 4.4.2 through Sec. 4.6. The materials shall be selected from those listed in Table 1 and the plate, sheet, or coils used for fabrication shall meet the requirements of ASTM A240/A240M or ASTM A480/A480M.

4.2.4 *Selection of materials.* The purchaser shall specify the materials to be used.

Table 1 Mechanical properties for austenitic or duplex stainless steel

		Tensile Strength, Minimum		Yield Strength, Minimum	
Alloy	UNS Number	*ksi*	*(MPa)*	*ksi*	*(MPa)*
		Austenitic Alloys			
304L	S30403	70	485	25	170
316L	S31603	70	485	25	170
304	S30400	75	515	30	205
316	S31600	75	515	30	205
201	S20100	75	515	38	260
201LN	S20153	95	655	45	310
		Duplex Alloys			
2101	S32101	94	650	65	450
2202	S32202	94	650	65	450
2304	S32304	87	600	58	400
2003	S32003	95	655	65	450
2205	S32205	95	655	65	450

NOTE: Type 304/304L and Type 316/316L dual-certified products meet the standard grade mechanical properties and are suitable for welding.

Sec. 4.3 General Fabrication Requirements

4.3.1 *Drawings.* If drawings are required, they shall be subject to review by the purchaser.

4.3.2 *Calculations.* If the manufacturer is required to determine the wall thickness, the manufacturer's calculations shall be subject to review by the purchaser.

4.3.3 *Protective lining and coating.* The purchaser shall specify if and what type of protective lining and coating is required.

Sec. 4.4 Specific Fabrication Requirements

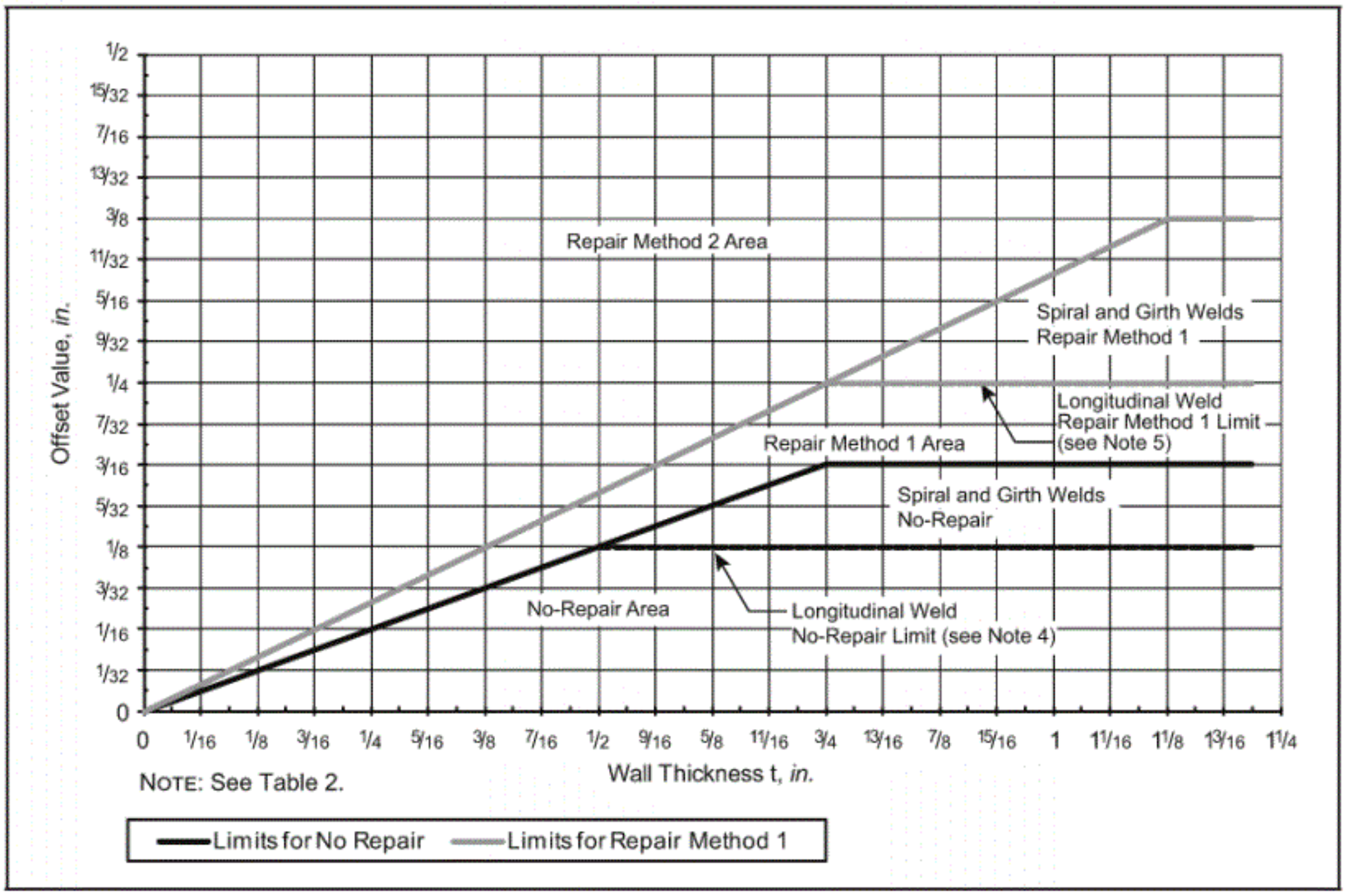
4.4.1 *General requirements.* Pipe produced according to one of the cited ASTM standards shall be subject to ANSI/AWWA C220 quality-assurance procedures and in compliance with applicable provisions of AWS D1.6/1.6M. Such pipe shall be manufactured to meet the requirements of ASTM A312/A312M, ASTM A409/A409M, ASTM A358/A358M, ASTM A778/A778M, ASTM A790/A790M, or ASTM A928/A928M using one of the types listed in Table 1. As an alternative, the pipe shall be fabricated in compliance with Sec. 4.4 and 4.9. Pipe produced in accordance with A778/A778M shall be pickled.

4.4.2 *Fabrication of pipe.* The leading edges of the sheet or plate shall be shaped by pressing or by rolling to the required pipe diameter. Hammering the leading edges to shape shall not be permitted. The plate or sheet shall then be final formed to the required pipe diameter and may be tacked welded prior to welding. The weld shall be of reasonably uniform width and height for the entire length of the pipe. The weld shall be made by an automatic means, unless the purchaser and the manufacturer agree to accept manual welding by qualified welders.

4.4.2.1 Welded butt joints. Spiral, longitudinal, and girth seams used in the manufacture of the pipe shall be complete joint penetration (CJP) welded butt joints. For wall thickness, t, the allowable radial offset (misalignment) is determined by Figure 1 or by Table 2.

Offset shall be measured with commercially available equipment, such as a Bridge Cam gauge. Two measurements shall be taken. The two measurements shall be taken on the same surface, perpendicular to the weld, one on each side of the weld. Both measurements shall be taken either across the inside weld, or across the outside weld of the pipe. The offset value is the absolute value of measurement one (O_1) minus measurement two (O_2) divided by two ($|[O_1 - O_2]/2|$).

Offsets determined to require repair by Figure 1 or Table 2 shall be repaired by the method indicated. In all cases, wall thickness through the finished weld



NOTES:

1. For thicknesses greater than shown, the "No-Repair" line does not exceed 3/16-in. measured offset.
2. For thicknesses greater than shown, the "Repair Method 1" line does not exceed 3/8-in. measured offset.
3. Lines in the figure are considered part of the area below them.
4. Longitudinal weld seams are subject to the limitation curves, but with a maximum allowable offset of 1/8 in. before repair is necessary.
5. Longitudinal weld seams are subject to the limitation curves, but with a maximum allowable offset of 1/4 in. before Repair Method 2 is necessary.

Source: Reprinted from ANSI/AWWA C200.

Figure 1 Repair method by offset value and wall thickness

Table 2 Repair requirements based on offset value and wall thickness

Measured Offset	Repair Required	Repair Method
Spiral and Girth Welds		
≤ Minimum [3/16 in., *t*/4]	No	None
Minimum [3/16 in., *t*/4] < Offset ≤ Minimum [3/8 in., *t*/3]	Yes	1
> Minimum [3/8 in., *t*/3]	Yes	2
Longitudinal Weld		
≤ Minimum [1/8 in., *t*/4]	No	None
Minimum [1/8 in., *t*/4] < Offset ≤ Minimum [1/4 in., *t*/3]	Yes	1
> Minimum [1/4 in., *t*/3]	Yes	2

Source: Reprinted from ANSI/AWWA C200.

seam shall be maintained. The manufacturer should take reasonable precautions to minimize recurring imperfections, damage, and defects.

Repair Method 1

a. Provide a minimum 3:1 taper over the width of the finished weld, or if necessary, add additional weld metal beyond what would otherwise be the edge of the weld to achieve a continuous 3:1 transition across the offset.

b. Offsets may also be repaired by removing the weld metal, realigning the material, and welding in accordance with the welding requirements of this standard.

Repair Method 2

a. Remove the weld metal, realign the material, and weld in accordance with the welding requirements of this standard.

b. Optionally, the method described in paragraph "a" under Repair Method 1 may be used if a representative weld test specimen with the maximum offset that has been repaired by such method, complies with the requirements of Sec. 4.4.3.

4.4.2.2 Weld preparation. Weld areas shall be free of oxide, oil, grease, and other contaminants prior to welding. The weld root shall be protected from oxidation by using inert-gas backing purge or other suitable measures.

During manufacture, fabrication, and handling, care should be taken to avoid contact or contamination with any ordinary carbon steel, sulfur, or low-melting-point metals such as zinc, lead, and copper.

4.4.2.3 Marking. Marking ink and identifying crayons should be free of zinc, lead, copper, iron, and sulfur.

4.4.3 *Requirements for welding operations.*

4.4.3.1 Welding procedures. Welding procedures shall be qualified under ASME Boiler and Pressure Vessel Code (BPVC), Sec. IX, or under AWS D1.6/1.6M.

4.4.3.2 End welding. If not done by automatic/machine submerged-arc or automatic/machine shielded-arc welding, end welding of longitudinal seams of fusion-welded pipe shall be performed by manual welding in accordance with Sec. 4.4.3.4 and 4.4.3.4.1.

4.4.3.3 Automatic welding. Longitudinal, spiral, and girth seams of straight pipe sections and special sections, when practical, shall be welded with an automatic welding machine. On request, sample welds shall be submitted to the purchaser for testing.

4.4.3.4 Manual welding. Manual welding of girth seams is permitted on straight pipe sections consisting of more than one full length (random or specified) unless otherwise specified. Manual welding of special sections and fittings is permitted when it is impractical to use an automatic welding machine. On straight pipe sections, manual welding shall be permitted only for tack welding of coils and plates during the continuous pipe-making process, in making a weld on the inside of the pipe, in rewelding and repairing structural defects in the plate and automatic machine welds, and as otherwise permitted by Sec. 4.4.2 of this standard.

4.4.3.4.1 Welders and welding operators shall be qualified under ASME Boiler and Pressure Vessel Code, Sec. IX, or under AWS D1.6/1.6M.

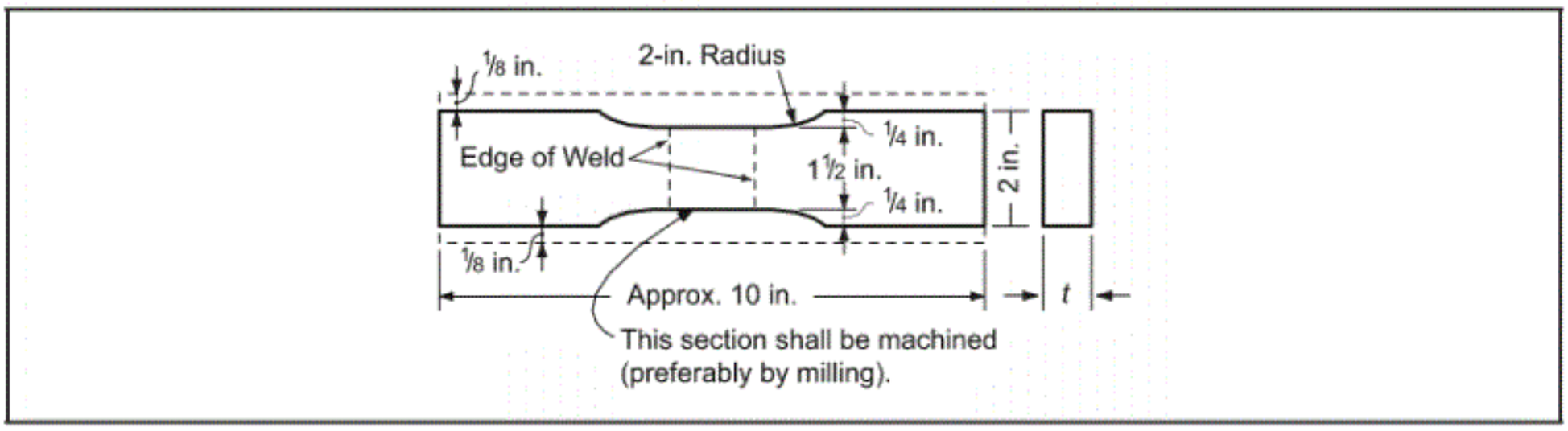
4.4.3.5 Welder and welding operator tests. The purchaser shall have the right to call for and witness the making of weld tests by any welder or welding operator, in accordance with Sec. 4.4.3.4.1, at any time the purchaser believes satisfactory welding is not being performed.

4.4.3.6 Test of production welds. Welding performance shall be checked during production using the tests and test values specified in Sec. 4.4.3.6.1 through Sec. 4.4.3.6.4.

4.4.3.6.1 The weld-test specimens shall be taken perpendicularly across the weld and from the end of the pipe or from test plates made of material conforming to the requirements of the plate specifications used in the manufacture of the pipe. Test plates shall be welded using the same procedure and by the same operator and equipment and in sequence with the welding of the longitudinal or spiral joints in the pipe. The test plates shall have the weld approximately in the middle of the specimen. The specimens shall be straightened and tested at room temperature.

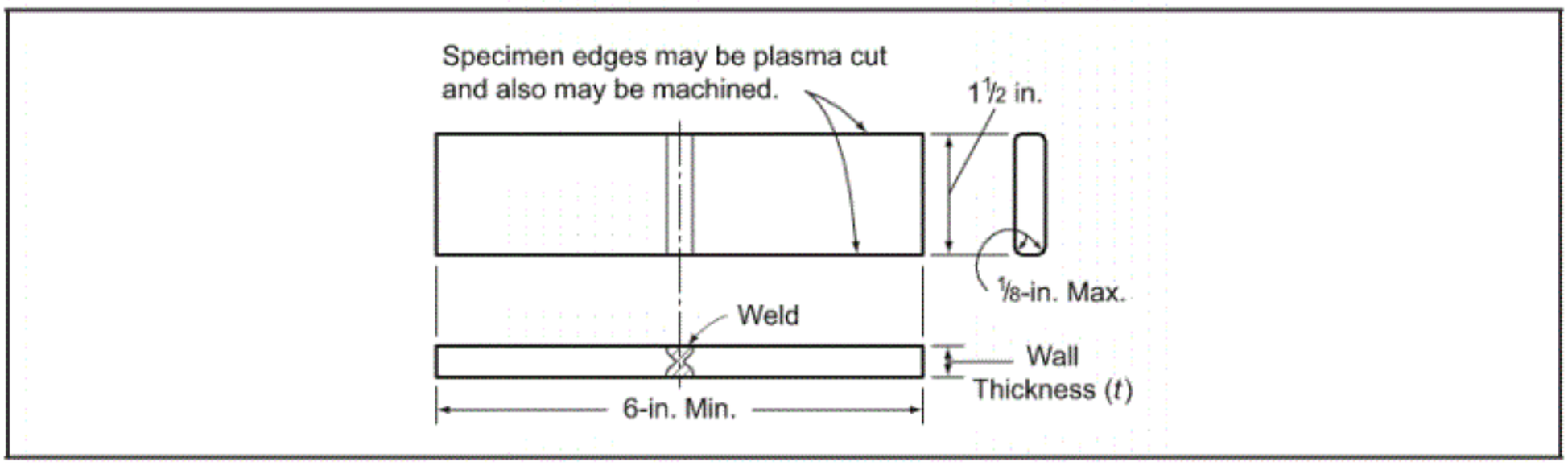
4.4.3.6.2 Two reduced-section tension specimens made in accordance with Figure 2 shall show a tensile strength not less than 100 percent of the minimum specified tensile strength of the base material used.

4.4.3.6.3 Two bend-test specimens shall be prepared in accordance with Figure 3 and shall withstand a 180-degree bend in a jig in accordance with Figures 4, 5, or 6. When making the guided-bend tests, one specimen shall be bent so that the face representing the inside of the pipe is on the inside of the test bend. The second bend test shall be made so that the face of the specimen representing the inside of the pipe is on the outside of the test bend. A guided-bend test specimen shall be considered to have passed if no crack or other open defect exceeding ⅛ in. (3.2 mm) measured in any direction is present in the weld metal or between the weld and base material after the bending.



NOTES:
1. Weld reinforcement or flash may or may not be removed flush with base metal.
2. To convert inches (in.) to millimeters (mm), multiply by 25.4

Figure 2 Reduced-section tension test specimen



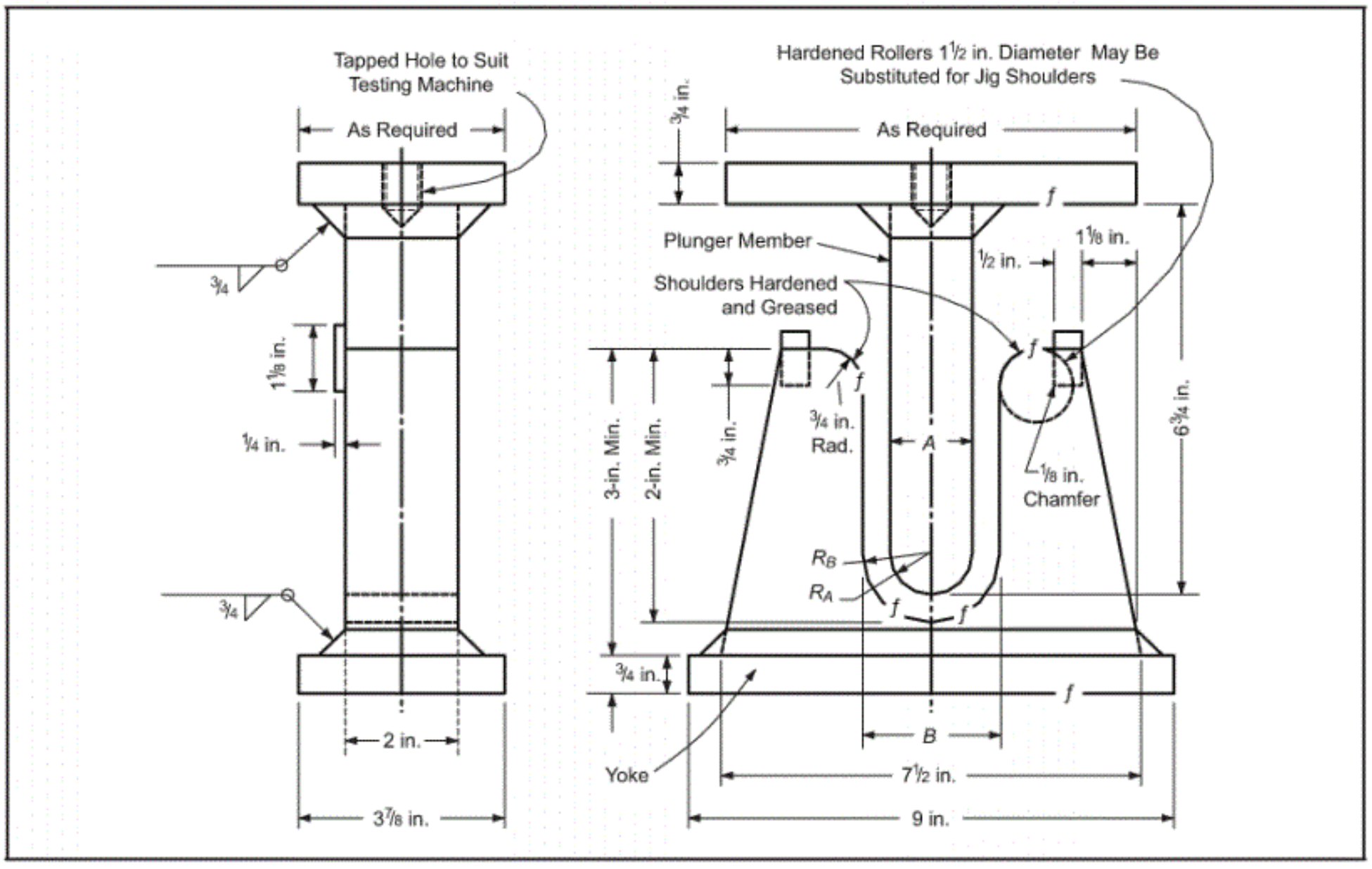
NOTES:
1. Weld reinforcement or flash need not be removed flush with base metal.
2. To convert inches (in.) to millimeters (mm), multiply by 25.4

Figure 3 Guided-bend test specimen

4.4.3.6.4 Etching tests for complete joint penetration production welds shall be performed on normal production welds. Complete joint penetration is defined in AWS A3.0M/A3.0. Verification of complete joint penetration shall be done by means of one macroetch of the joint weld cross section and shall be performed with the same frequency as the guided-bend test. The macroetch technique shall be as prescribed in ASTM E340.

4.4.3.6.5 If any test specimen shows defective machining or develops flaws not associated with the welding, it shall be discarded and another specimen substituted.

4.4.3.7 Frequency of production weld test. Weld tests are required if there is a change in any of the following: welding procedure, specified diameter, specified thickness, operator, or welding equipment. Weld tests shall be conducted



NOTES:

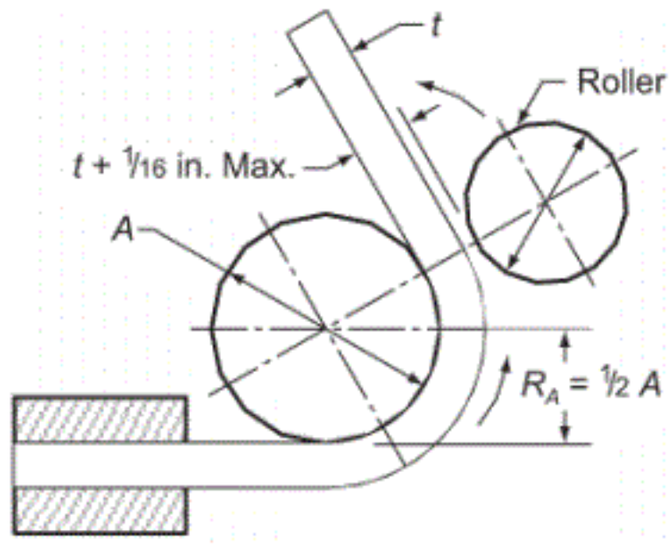
1. See Table 3 for jig dimensions.
2. The symbol *f* indicates a light finish cut; *t* is the specified wall thickness of pipe.
3. See Figures 5 and 6 for alternative guided-bend test fixtures.
4. To convert inches (in.) to millimeters (mm), multiply by 25.4.

Figure 4 Jig for guided-bend test

Table 3 Guided-bend test jig dimensions

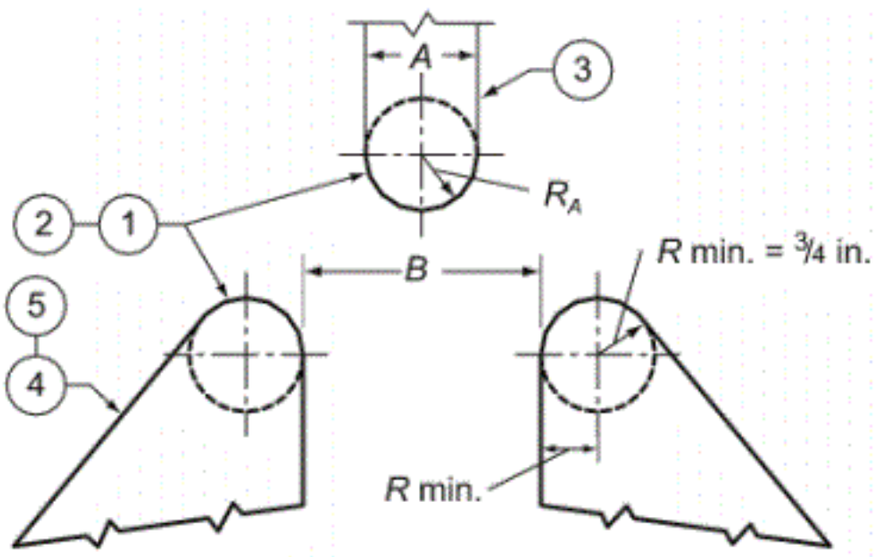
	Specified Minimum Yield Strength Up to 42,000 psi (290 MPa)
Radius of male member R_A	$2t^*$
Radius of female member R_B	$3t$ + ⅛ in. (1.6 mm)
Width of male member A	$4t$
Width of groove in female member B	$6t$ + ⅛ in. (3.2 mm)

*t ≤ Specified wall thickness of the pipe.



NOTES:
1. Dimensions not shown are the option of the designer. The essential consideration is to have adequate rigidity so that the jig parts will not spring.
2. The specimen shall be firmly clamped on one end so that there can be no sliding of the specimen during the bending operations.
3. Test specimens shall be removed from the jig when the outer roll has been removed 180° from the starting point.
4. To convert inches (in.) to millimeters (mm), multiply by 25.4.

Figure 5 Alternative guided-bend wraparound jig



NOTES:
1. Either hardened and greased shoulder or hardened rollers free to rotate shall be used.
2. The shoulders or rollers shall have a minimum bearing surface of 2 in. (51 mm) for placement of the specimen. The rollers shall be high enough above the bottom of the jig so that the specimens will clear the rollers when the ram is in the low position.
3. The ram shall be fitted with an appropriate base and provision made for attachment to the testing machine, and shall be designed to minimize deflection and misalignment. The ram to be used with the roller jig shall be of identical dimensions to the ram shown in Figure 4.
4. If desired, either the rollers or the roller supports may be made adjustable in the horizontal direction so that specimens of *t* thicknesses may be tested on the same jig.
5. The roller supports shall be fitted with an appropriate base designed to safeguard against deflection or misalignment and equipped with means for maintaining the rollers centered, midpoint, and aligned with respect to the arm.
6. The weld and heat-affected zone in the case of a transverse-weld bend specimen shall be completely within the bend portion of the specimen after testing.
7. To convert inches (in.) to millimeters (mm), multiply by 25.4.

Figure 6 Alternative guided-bend roller jig

at a maximum interval of once per every 3,000 ft (915 m) of pipe, per pipe manufacturing process, except as required under Sec. 4.4.3.4.

4.4.3.8 Retests. If a tested specimen fails to meet the requirements, retests of two additional specimens from the same pipe lot shall be made, each of which shall meet the requirements specified. A "pipe lot" is defined as all pipe between the failed test and the previous successful test. If such specimens conform to the specified requirements, all lengths from the lot shall be accepted, except the length initially selected for testing. If any of the retested sections fail to conform to the requirements, the entire lot shall be rejected. Test specimens may be taken from each untested pipe length at the manufacturer's option, and each specimen shall meet the requirements specified or that pipe shall be rejected.

4.4.3.9 Weld repair. See Sec. 5.4 for requirements

Sec. 4.5 Permissible Variations in Weights and Dimensions

4.5.1 *Thickness and weights.* Unless otherwise specified by the purchaser, the wall thickness and weight tolerances for welded pipe shall be governed by the requirements of the specifications to which the plates or sheets are ordered.

4.5.2 *Circumference.* The outside circumference of the pipe shall be the lesser of ±1.0 percent or ¾ in. (19 mm) from the outside circumference, based on the diameter specified, except that the circumference at ends shall be sized, if necessary, to meet the requirements of Sec. 4.6.

4.5.3 *Straightness.* The maximum deviation from a straight line, over the entire length of the pipe, shall be 0.2 percent of the pipe length measured with a taut wire or string.

4.5.4 *Lengths.* Pipe lengths shall be supplied as follows:

4.5.4.1 Specified lengths. Specified lengths shall be furnished with a tolerance of ±2 in. (51 mm). This tolerance does not apply to the shorter lengths from which test coupons have been cut.

4.5.4.2 Random lengths. Random lengths may be furnished if approved by the purchaser. The manufacturer must give a minimum and maximum length to the purchaser for approval.

4.5.4.3 Girth welds. Pipe lengths containing girth welds (Sec. 4.4.2.1) shall be permitted.

4.5.5 *Out-of-roundness.* For pipe diameters less than or equal to 48 in. (1,200 mm), the outside diameters shall not exceed the variations as listed in ASTM A999/A999M. For pipe diameters larger than 48 in (1,200 mm), the

outside diameter variation shall not exceed ±1.0 percent of specified diameter when measured in accordance with ASTM A999/A999M.

Sec. 4.6 Preparation of Ends

4.6.1 *General.* Pipe ends shall be smooth and free from notches, weld spatter, and burrs.

4.6.2 *Ends for mechanically coupled field joints.* Ends for mechanically coupled field joints shall be plain or grooved. Tolerances shall be within the limits required by the manufacturer of the type of coupling to be used. The outside of ends of plain-end pipe shall be free from surface defects and shall have the longitudinal or spiral welds ground flush with the surface for a sufficient distance from the ends to permit the pipe to make a watertight joint with the coupling. Grooved ends shall be prepared to fit the type of mechanical coupling to be used and in accordance with ANSI/AWWA C606. Plain ends shall be prepared to fit the type of mechanical coupling to be used in accordance with ANSI/AWWA C219 or ANSI/AWWA C227 as appropriate.

4.6.3 *Plain-end pipe.* Pipe shall be furnished with a plain right-angle cut. All burrs and sharp corners at the ends of the pipe shall be removed.

4.6.4 *Beveled ends for field butt welding.* For field butt welding of circumferential joints, the ends shall be beveled to an angle of 37.5 degrees, measured from a line drawn at right angles to the axis of the pipe, with a tolerance of ±2.5 degrees, and with a width of root face (or flat at the end of the pipe) of 1⁄16 in. ±1⁄16 in. (1.6 mm ±1.6 mm). Other bevel angles may be used if prior approval between purchaser and constructor is obtained. Bevel angles shall be in accordance with approved welding procedure specifications (WPSs).

4.6.5 *Ends fitted with butt straps for field welding.* Ends of pipe to be fitted with butt straps for field welding shall comply with details supplied by the purchaser. Butt straps may be made in segments or as complete cylinders. Butt strap thickness shall be no less than the pipe-wall thickness and assembled butt strap shall overlap pipe no less than 1 in. (25 mm). Butt straps shall be welded to the pipe by the manufacturer or shipped separately, as specified by the purchaser. The weld at the pipe ends and inside the butt straps shall be ground flush with the plate surfaces for a distance sufficient to facilitate installing the butt strap.

4.6.6 *Belled-end socket welds.* Belled-end socket welded piping and fittings are a family of wrought tubular products. Tolerances, socket dimensions, and pipe fillet weld joints are detailed in MSS SP-119.

4.6.7 *Manufacturing tolerances at ends.* Tolerances for pipe ends shall be in accordance with Sec. 4.6.7.1 and 4.6.8, as applicable. The length of the pipe subject to the stated tolerance shall be that distance that comes in direct contact with the mating pipe or external appurtenances.

4.6.7.1 Diameter. The diameter of the pipe ends shall be as determined by accurate circumferential measurement with a steel tape.

4.6.7.1.1 The circumference of the following types of pipe ends shall not vary by more than 0.196 in. (5.0 mm) under, or 0.393 in. (10.0 mm) over, the specified outside circumference:

1. Plain-end pipe
2. Beveled ends for field butt-joint welding
3. Plain ends fitted with flanges
4. Ends fitted with butt straps for field welding

NOTE: These circumferential tolerances are equivalent to –1/16 in. (–1.6 mm), +1/8 in. (+3.2 mm) on the resultant calculated diameter.

4.6.7.1.2 Ends for mechanical couplings shall have tolerances within the limits required by the manufacturer of the coupling to be used.

4.6.8 *Squareness of ends for field welded butt joints.* For pipe that is to be butt-welded in the field, the ends of pipe sections shall not vary by more than 1/8 in. (3.2 mm) at any point from a true plane perpendicular to the axis of the pipe.

Sec. 4.7 Special Ends

By agreement between the manufacturer and the purchaser, the ends of the pipe may be supplied with joint configurations and tolerances other than those specified in this standard. In such cases, pipe ends shall conform to detail drawings reviewed by the purchaser.

Sec. 4.8 Cleaning and Descaling

The pipe shall be free from scale and contaminating iron particles. Contaminating iron particles and heat tint shall be removed, in accordance with ASTM A380/A380M or other methods acceptable to the purchaser.

Sec. 4.9 Specials and Fittings

4.9.1 *General.* Special sections that may be required shall be specified by the purchaser and shall have dimensions conforming to ANSI/AWWA C226, unless otherwise specified by the purchaser. The purchaser shall specify the maximum miter angle and center-line radius of elbows, special treatment of ends, orientation of laterals, and other dimensional details not defined in ANSI/AWWA C226. Special

sections not included in ANSI/AWWA C226 shall be fabricated according to the detailed descriptions or drawings furnished by the purchaser or according to the manufacturer's drawings that have been approved by the purchaser.

4.9.2 *Fabrication of specials.* Special sections may be fabricated from pipe provided that the pipe meets the requirements of this standard. Special sections that are not fabricated from pipe may be made from any of the materials referenced in Sec. 4.2.

4.9.2.1 Flange connections. Flanges shall meet the requirements of ANSI/AWWA C228, and the materials for the flanges shall be the same material as listed in Table 1 of this standard or as specified by the purchaser. Rolled stainless-steel angle face rings with follower flanges may be provided when specified by the purchaser.

SECTION 5: VERIFICATION

Sec. 5.1 Inspection

Work performed and material furnished under the provisions of this standard may be inspected by the purchaser, but such inspection shall not relieve the manufacturer of responsibility to furnish material and perform work in accordance with this standard. If the purchaser elects to inspect the pipe or witness the tests, the manufacturer shall provide reasonable notice of the time at which the inspection may be made.

5.1.1 *Quality assurance.* The manufacturer shall maintain a quality-assurance program to ensure that minimum standards are met. It shall include a certified welding inspector (AWS QC1) to verify that welders and welding procedures are qualified, that procedures are being followed within the limitations of testing, and that quality-assurance functions are being implemented.

5.1.2 *Access and facilities.* While work on the purchaser's project is being performed, the purchaser shall be allowed entry to the manufacturer's plant where materials are manufactured. The manufacturer shall afford the purchaser reasonable facilities necessary to determine if the material is being furnished in accordance with this standard. Tests and inspections shall be made at the place of manufacture before shipment. Hydrostatic testing, if specified by the purchaser, may be performed as part of the completed installation hydrostatic leak and pressure test.

5.1.3 *Rejection.* The purchaser may reject pipe sections or special sections that do not conform to the prescribed test results and tolerances set forth in this standard and as specified by the purchaser.

Sec. 5.2 Test Procedures

5.2.1 *Testing procedures.* Each length of pipe shall be tested by one of the following methods. The method of testing may be specified by the purchaser. If the method of testing is not specified, the manufacturer shall select the method of testing.

5.2.1.1 Hydrostatic test. When specified by the purchaser, each length of pipe shall be tested by the manufacturer to a hydrostatic pressure not less than that determined by the following formula:

$$p = 2St/D$$

Where:

p = minimum hydrostatic test pressure, psi (kPa)
S = stress in pipe wall during hydrostatic test, in psi (kPa), which shall be 0.75 times the specified minimum yield strength of the material used, or as specified by the purchaser
t = nominal wall thickness as specified, in. (mm)
D = outside diameter, in. (mm)

The test pressure shall be held for sufficient time to observe the weld seams but not less than 30 seconds. There shall be no leaks. Any leaks in the welded seams shall be repaired in accordance with Sec. 5.4, after which the pipe section shall be retested hydrostatically. If on retest a section shows any leaks in the welded seams, the section shall be rejected. Stainless-steel pipe requiring hydrostatic testing shall be tested using potable water with less than 250 parts per million chloride content. All water shall be drained to avoid a stagnant condition or the pipeline placed in immediate service.

5.2.1.2 Liquid dye penetrant test. Liquid dye penetrant tests shall be performed in accordance with the requirements of ASME BPVC, Section VIII, Appendix 8, Methods for Liquid Penetrant Examination.

5.2.1.3 Eddy current test. Eddy current testing shall be performed in accordance with ASTM E426.

5.2.1.4 Other testing. Radiographic, ultrasonic, or visual testing methods may be used if specified by the purchaser. If the purchaser specifies the method of testing, the purchaser shall also specify the standard by which that method shall be performed by the manufacturer.

5.2.1.5 Seamless pipe. Seamless pipe is not subject to testing unless specified by the purchaser.

5.2.2 *Testing of special sections and fabricated spools.*

5.2.2.1 Nondestructive testing. Special sections shall be tested by nondestructive testing methods, which may be dye penetrant, ultrasonic, radiographic, or visual weld examination, when specified by the purchaser. These tests and acceptance criteria shall be in accordance with the procedures and acceptance criteria of AWS D1.6/1.6M, Paragraph 6.28, Quality of Welds, Statically Loaded; ASME BPVC, Section VIII, Division 1; or any other code mutually acceptable to the purchaser and manufacturer. Special sections fabricated from previously hydrostatically tested straight pipe require testing of only those welded seams that were not previously tested in the straight pipe.

5.2.2.2 Hydrostatic testing. When specified by the purchaser or when required by service conditions, special sections may be tested in a hydrostatic testing machine, or as part of the completed installation hydrostatic leak/pressure test, in place of nondestructive testing referred to in Sec. 5.2.2.1. Special sections that cannot be tested in a hydrostatic testing machine may be hydrostatically tested by welding on heads, by use of blind flanges or mechanical couplings, or as otherwise specified by the purchaser. After testing, the ends shall be reconditioned when necessary. The required pressure shall be maintained long enough to permit visual inspection of seams but not less than 30 seconds. Any section showing leaks or injurious defects shall be repaired in accordance with Sec. 5.4. Repaired sections shall be retested.

5.2.2.3 Test certification. After testing, sections that pass the test(s) may be labeled by the purchaser with some legible mark or identification, or the purchaser may request a certificate from the manufacturer concerning results of the tests.

Sec. 5.3 Basis for Rejection

5.3.1 *General.* Material may be rejected and the manufacturer so notified if the material shows injurious defects when it is source inspected at the mill, or after it is accepted at the manufacturer's plant, or if it proves defective when properly installed and applied in service. In the event of such defects or errors in selecting materials, associated materials, or wall thicknesses and if it is permitted according to this standard, the manufacturer shall repair or replace such material.

5.3.2 *Defects.* The finished pipe shall be free from injurious defects. Defects in the parent metal of welded pipe shall be considered injurious when

the depth of the defect is greater than 12.5 percent of the nominal wall thickness. Cracks and leaks in welds shall be considered injurious.

Sec. 5.4 Repair of Defects

The repair of injurious defects will be permitted provided repair methods conform to the following requirements.

5.4.1 *Removing defect.* The defect shall be completely removed and the cavity cleaned using stainless-steel tools. Oil, grease, or contamination shall be removed from the area prepared for welding using appropriate cleaning agents and methods.

5.4.2 *Repair weld.* The repair weld shall be made using qualified welding processes by a welder qualified in accordance with Sec. 4.4.3.4.1.

5.4.3 *Testing repaired pipe.* Each length of repaired pipe shall be tested hydrostatically in accordance with Sec. 5.2.1.

SECTION 6: DELIVERY

Sec. 6.1 Marking

A serial number or other identification shall be stenciled where it is easily seen on each section of pipe and each special section, away from any areas to be welded. The use of any injurious marking devices shall not be acceptable. If the pipe is coated or lined, such marking shall be performed at the shop and later transferred to the coating or lining. The manufacturer may be required to provide the purchaser with line diagrams or laying schedules, showing where each numbered pipe or special section belongs in the line. The numbers on such diagrams or schedules shall correspond with those stenciled on the pipes and special sections.

Sec. 6.2 Shipping, Storage, and Handling

Pipe shall be handled in a manner that prevents distortion or damage. Ferrous metals, such as carbon steel and cast ductile iron, shall not be allowed to come into direct contact with stainless steel. If carbon-steel devices are used to handle the pipe, they shall be covered so as to not contact the pipe. The use of hooks or clamps shall not be permitted. Pipe shall be loaded in a manner that prevents projections on any pipe length, such as ends with lap joints or ends with bells and spigots for rubber-gasketed joints, from rubbing against one another or against another pipe length. The use of nonmetallic slings is acceptable.

6.2.1 *Out-of-roundness.* Pipe shall be loaded so as to ensure that out-of-roundness does not exceed the limits specified by the purchaser.

6.2.2 *Transport and handling.* Stainless-steel pipe shall be transported and handled as specified by the purchaser.

6.2.3 *Finished pipe at delivery destination.* Shipments received at the delivery destination should be inspected for damage before they are unloaded. Any pipe section or special section that shows dents, kinks, or injuries on delivery may be rejected. A brief description of the damage and the reasons for rejection should be noted on the bill of lading and initialed by the carrier's representative. Photographs, video, or other media documentation of the damage shall also be sent to the manufacturer. The manufacturer shall repair or replace the rejected sections subject to the purchaser's review.

6.2.3.1 Reconditioning. Reconditioning of rejected sections shall be accomplished by re-rolling or by pressure but not by hammering. Reconditioned sections shall be retested hydrostatically at the required pressure, if required.

6.2.3.2 Storage. Materials should be stored on skids or by using appropriate means to isolate them from ferrous metals and to prevent damage and contamination from the ground.

6.2.3.3 Walking or standing on pipe. Walking or standing on the pipe should be avoided to prevent physical damage.

6.2.3.4 Capping. Ends shall be capped if specified by the purchaser.

Sec. 6.3 Affidavit of Compliance

The purchaser may require an affidavit from the manufacturer that the pipe, specials, fittings, and other products or materials provided comply with applicable requirements of this standard.

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