Revision of the AWWA C200 Steel Water Pipe Manufacturing Standard: Consensus-Based Changes Mark Significant Improvements

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ABSTRACT

AWWA C200 Steel Water Pipe, 6 Inch and Larger, is an industry consensus standard that is recognized throughout the world and is the preeminent guide for the manufacture of steel pipe for water and wastewater applications in North America. The first AWWA steel water pipe standards, 7A.3 and 7A.4 were published in 1940. In 1949, 7A.3 was replaced with C201 and 7A.4 was replaced with C202. These two standards were later combined into the C200 standard in 1975. Since then, the document has undergone six revisions, each iteration marked by improvements to the manufacturing process as well as associated quality control procedures. The most recent revision, incorporating a number of significant updates, was approved by the AWWA Board of Directors on June 22, 2012 and became effective on September 1, 2012.

This paper will provide a historical perspective of AWWA steel water pipe standards, followed by a discussion of some substantial improvements made in the latest revision of C200. Topics discussed will include considerations for the Charpy toughness or impact testing, new testing requirements for gasket materials, allowable steel grades and or characteristics, manufacturing test requirements, weld procedures and weld testing.

HISTORY OF AWWA STEEL WATER PIPE STANDARDS

Steel water pipe standards have been around in one form or another since the early installations of the product near the turn of the previous century. The following is a brief history of steel water pipe and the standards that eventually governed its manufacture.

History of Steel Water Pipe

A history of steel water pipe in the US can be found in AWWA M11 (2004) as well as other documents written on the subject. Cates (1971) discusses wrought iron pipes being developed and installed in the early nineteenth century. Later with the advent of the Bessemer process in the 1850's, the Age of Steel was born. The Bessemer process reduced the carbon content of molten iron and removed impurities to form steel and also allowed for the mass production that previously was unobtainable. This allowed industry to tap into the superior properties of steel that had been difficult and expensive to obtain previously. During this same period the first steel water pipes were manufactured and installed in the US, with the first recorded installation in 1858 (Cates 1971).

The first steel pipe used rivets to join the seams (see Figure 1). This process was improved over the years and was common practice through the 1930's. Around that time the improvements to the process of welding started to make it the preferred choice to join pipe seams together, although field joints were still typically riveted as portable welding equipments was not common.

Figure 1 : Riveted Steel Pipe Joint

Another joining method that was developed in 1905 gained popularity up through the common use of welding in pipe manufacturing. Called Lock-Bar pipe (see Figure 2), it used H shaped bars to joint two half circle steel plates with upset edges together by hydraulic pressure. , The joint was considered to be 100% efficient and therefore quickly gained acceptance. By the mid 1920's Lock Bar had taken on a major role in the industry, but as with riveted pipe was eventually replaced by welding.

Figure 2 : Lock-Bar Pipe Joint

Helically welded steel pipe was developed in the 1930's and was used extensively in diameters of 4 through 36 inch. After WWII German technology was brought to the US, helically welded diameters through 144 inch became possible (see Figure 3).

Figure 3 : Spiral Welded Steel Pipe, 126" Diameter (During Hydrotest)

Steel pipelines produced to the original AWWA steel water pipe standards are still serving admirably in water systems today. Over the subsequent years since the publication of the first AWWA steel water pipe standard, welding and forming technology has improved considerably, as has steel production and coatings. The improvements incorporated in the AWWA Standards of today give the industry steel water pipe that is unmatched in quality and durability by previous generations.

Predecessors of AWWA C200

Before the first published standard for steel water pipe by AWWA, other standardization agencies such as Underwriter Laboratories (1938) were already writing steel water pipe standards. In 1939 however a committee A7A, the Steel Plate Pipe Committee of the American Water Works Association was formed, the predecessor of AWWA Standards Committee on Steel Pipe. At the same time a subsidiary group, the Steel Water Pipe Technical Advisory Committee (now known as SWPMTAC, the Steel Water Pipe Manufacturers Technical Advisory Committee) was formed as a technical information source for the parent committee and is still very active today. Committee A7A was succeeded by 8310D, the Water Works Practice Committee, and then the current AWWA Standard Committee on Steel Pipe. This committee is currently responsible for 25 Standards and one manual relating to steel pipe, including AWWA C200.

In 1940 and 1941 two steel pipe standards were published, AWWA Standard 7A.3 (1940) (see Figure 4), Electric Fusion Welded Steel Water Pipe Of Sizes 30 Inches And Over and AWWA Standard 7A.4 (1941) (see Figure 5)Steel Water Pipe Of Sizes 4 Inches Up To But Not Including 30 Inches. The main differences between the standards can be seen in their respective scopes.

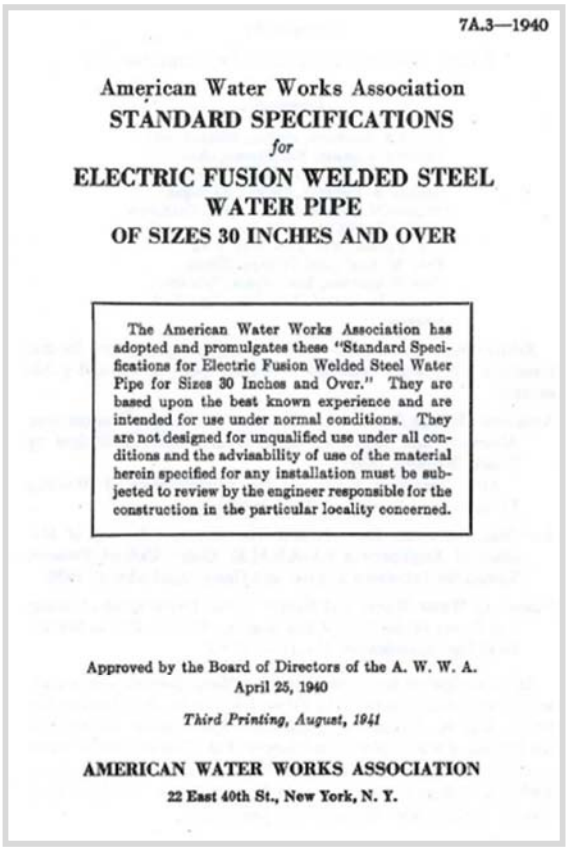
The scope of AWWA 7A.3-40 states:

"These specifications cover the manufacture of straight seam or spiral seam electric fusion welded steel pipe, intended for the conveyance of water, which is thirty (30) inches and greater in diameter and is in twenty (20) feet and longer laying length straight sections or other special sections which are required for closures, curves, changes in alignment or grade to meet special conditions. The contractor, as bidder, shall submit to the

purchaser the details of the procedure he proposes to use in the fabrication of the pipe and special sections and the procedure shall comply with specifications given hereinafter."

The scope of AWWA 7A.4-41 states in part:

"These specifications cover steel pipe intended for the conveyance of water, in sizes of 4 inches up to but not including 30 inches in diameter, and in random, double random or specified laying lengths, straight sections, or other special sections which are required for closures, curves, changes in alignment or grade to meet special conditions and with ends prepared for type of joint specified. The manufacturer or bidder shall state to the purchaser the type of pipe manufacture he proposes to use in the production of mill pipe or details of the procedure he proposes to use in the manufacture of fabricated pipe and special sections. This manufacturing procedure shall comply with the specifications given hereinafter unless otherwise agreed to by the engineer, purchaser, or authorized inspector during the progress of the work.



7A.3—1940

American Water Works Association
STANDARD SPECIFICATIONS
for
ELECTRIC FUSION WELDED STEEL WATER PIPE
OF SIZES 30 INCHES AND OVER

The American Water Works Association has adopted and promulgates these "Standard Specifications for Electric Fusion Welded Steel Water Pipe for Sizes 30 Inches and Over." They are based upon the best known experience and are intended for use under normal conditions. They are not designed for unqualified use under all conditions and the advisability of use of the material herein specified for any installation must be subjected to review by the engineer responsible for the construction in the particular locality concerned.

Approved by the Board of Directors of the A. W. W. A. April 25, 1940

Third Printing, August, 1941

AMERICAN WATER WORKS ASSOCIATION
22 East 40th St., New York, N. Y.

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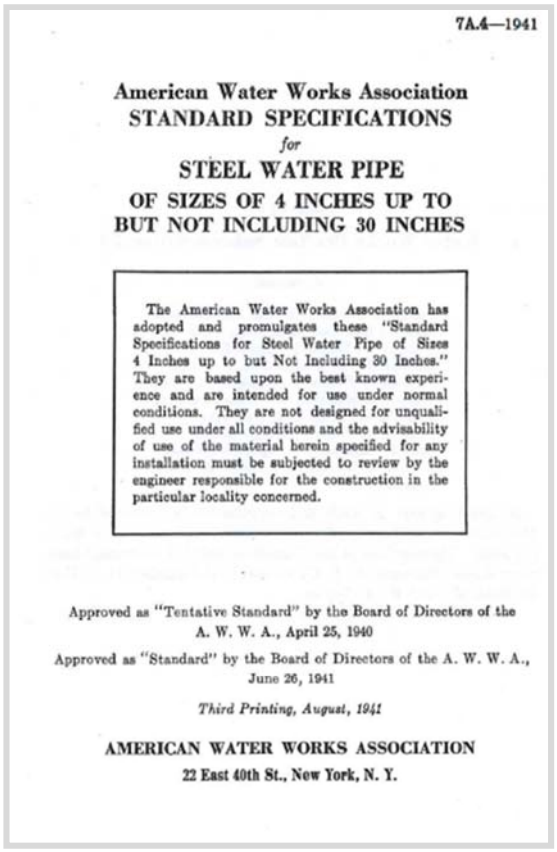
Figure 4 : AWWA 7A.3 – 40



7A.4—1941

American Water Works Association
STANDARD SPECIFICATIONS
for
STEEL WATER PIPE
OF SIZES OF 4 INCHES UP TO BUT NOT INCLUDING 30 INCHES

The American Water Works Association has adopted and promulgates these "Standard Specifications for Steel Water Pipe of Sizes 4 Inches up to but Not Including 30 Inches." They are based upon the best known experience and are intended for use under normal conditions. They are not designed for unqualified use under all conditions and the advisability of use of the material herein specified for any installation must be subjected to review by the engineer responsible for the construction in the particular locality concerned.

Approved as "Tentative Standard" by the Board of Directors of the A. W. W. A., April 25, 1940

Approved as "Standard" by the Board of Directors of the A. W. W. A., June 26, 1941

Third Printing, August, 1941

AMERICAN WATER WORKS ASSOCIATION
22 East 40th St., New York, N. Y.

Figure 5 : AWWA 7A.4 - 41

The contents of these standards were in many ways similar to that of the C200 standard today. They discussed manufacturing tolerances, weld testing, fitting manufacture, and hydrotesting of pipe. They also included some limited language on coating of steel pipe.

Steels in the two standards were listed differently. In 7A.3 the steel was specified as ASTM A283 "latest revision", Specification for Low and Intermediate Tensile Strength Carbon Steel Plates. In 7A.4 the steel was split into mill pipe and fabricated pipe. For fabricated pipe ASTM standard A78 Grade B "latest revision," Low Tensile Strength Carbon-Steel

Plates of Structural Quality for Welding was specified. It should be noted that at the time ASTM A283 was a tentative standard, and was in the process of replacing ASTM A78 (see Table 2). For mill pipe physical and chemical property limits were given (see Table 1).

Table 1: AWWA 7A.4 Mill Pipe Steel Physical Properties

Property	Bessemer Lap weld	Open Hearth Lap weld
Tensile Strength, psi	50,000	45,000
Yield Strength, psi	30,000	25,000
Elongation, 8 in gage	18%	22%

Table 2: ASTM A78 and ASTM A283 Physical Properties

Property	ASTM A78	ASTM A283 Gr A	ASTM A283 Gr B	ASTM A283 Gr C	ASTM A283 Gr D
Tensile Strength Min, psi	Not Specified	45,000 to 55,000	50,000 to 60,000	55,000 to 65,000	60,000 to 72,000
Yield Strength, psi	Not Specified	24,000	27,000	30,000	33,000
Elongation, 2 in gage	Not Specified	30%	27%	24%	22%

The footprint of these early standards can still be seen today, as many of the basic quality tests that were required for steel pipe at the time are still used today in some variation.

In 1943 a "tentative revision" of both 7A.4 and 7A.3 were produced. In the revisions, clarifications were made regarding pipe diameter tolerances, certain test pressures and reshaping of pipe.

In 1949 the tentative revision of 7A.4 was further revised and published under a new designation, AWWA C202-49 (1949) Steel Water Pipe of Sizes Up To But Not Including 30 Inches. That same year 7A.3 was replaced with AWWA C201-49 (1949) Electric Fusion Welded Steel Water Pipe Of Sizes 30 Inches and Over.

C201 (pipe 30 inches and larger in diameter) required steel to be ASTM A283 Grade B. Improvements in welding technology can be seen as qualification of welding operations was included in the standard.

C202 (pipe less than 30 inches in diameter) listed ASTM A283 Grade B for plate and ASTM A245 for sheet and coil for fabricated pipe. Mill pipe still listed chemical and physical properties and now included butt welding.

Some of the field joints listed in these standards included welded lap, butt and buttstrap joints. Mechanically coupled, flanged, riveted, and caulked joints as well as taper ends for "driven field joints" were also a part of this standard.

In 1959 both standards were revised to add more steel grades, ASTM A283 Grades C and D.

In 1960 both standards were given a tentative status and came with another major revision. C201 now covered all diameters of steel pipe that were manufactured in a fabricators shop from steel sheet or plate. C202 now pertained to all diameters of mill pipe, with the properties of the finished pipe being tested rather than the steel from which it was produced.

In 1964 C202 was revised and again given "tentative" status. Changes were made to the purchaser's details to be provided to the manufacturer and also to the inspection sections.

The 1966 revision to C201 saw substantial changes to the standard:

"Provision has been made to permit the contractor to determine the physical properties of the material from test specimens taken from the pipe after fabrication; provision has been made for purchasing the steel on a "chemical basis;" a section on affidavit of compliance has been added; important changes have been made for clarification in Sec. 6.3 regarding condition of pipe at delivery, rejection, and reconditioning; and several other changes have been made that are editorial in nature or that are for clarification of the intent of the standard."

First Edition of AWWA C200 - 1975

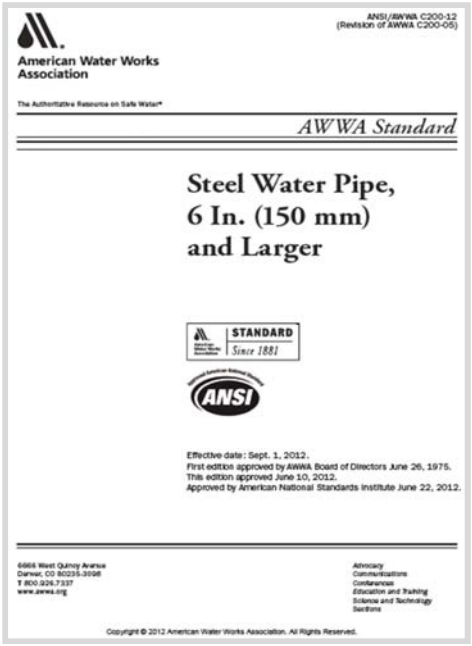
In 1975 the first edition of AWWA C200 (1975) Steel Water Pipe 6 Inches and Larger, was published, combining C201 and C202. The title was Steel Pipe 6 Inches and Larger. Beyond combining the two previous standards, including all steel water pipe types, the new standard also included language to assist in determining wall thickness due to pressure. Numerous other additions and changes were made including additional steel grades, testing of specials, rubber gasket material requirements, additional tolerances, and welding requirements and qualifications. The layout of the 1975 standard is still generally followed in today's version of C200.

Subsequent Editions: 1980, 1986, 1991, 1997, 2005

Over the next 30 years AWWA C200 was revised numerous times, improving the standard by updating references and keeping the standard up to date with the latest manufacturing capabilities. Some of the changes addressed were welding qualifications, weld misalignment, pipe and specials weld testing as well as numerous changes to help with clarifying the intent of the standard and improve overall quality of the finished pipe product.

AWWA C200-12 Major Revisions

The 2012 revision of AWWA C200 (2012) (see Figure 6), Steel Water Pipe, 6 In. and Larger, brought a large number of changes and additions. This included adding specific language for Charpy testing and the circumstances under which it should be required, clarifying some items related to weld testing, updating the gasket requirements and the list of acceptable steel grades. As has been done in previous updates, these changes have again strengthened the standard.


ANSI/AWWA C200-12
(Revision of AWWA C200-05)

American Water Works Association

The Authoritative Resource on Safe Water™

AWWA Standard

Steel Water Pipe, 6 In. (150 mm) and Larger

STANDARD Since 1881

ANSI

Effective date: Sept. 1, 2012.
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Figure 6 : AWWA C200 – 12

Testing (hydrotest, testing of specials)

In-plant hydrostatic testing has always been a part of C200. Many of the previous editions of the standard required the hydrotest to be held for a sufficient time to verify that there are no leaks in the welds of the pipe cylinder. In this edition it was added to the language that the hold time shall also not be less than 30 seconds. This minimum hold time is longer than other steel pipe standards, including ASTM, ASME and API.

Straightness

Checking pipe for straightness in the previous edition was verified by placing a 10 foot straightedge along the pipe; it was not allowed to have more than 1/8-inch deviation. This method was difficult to use due to the welds in the pipe. The 2012 version of C200 now states that straightness shall be within 0.2% along the entire length of the cylinder. The new requirement, taken over the length of the pipe, is more restrictive than the previous version, but was primarily incorporated to make the test procedure itself easier to accomplish.

Weld Testing and Welder Qualification

Numerous changes were made in the weld testing and welder qualification sections. For welder qualifications, a section was added stating that steel listed in the standard for the purpose of weld qualification are considered to be P-1 group 1, 2, or 3 materials when qualifying to ASME Section IX. This was done to eliminate confusion about the base materials. Coil materials are not specifically listed in ASME Section II. Since most steel water pipe is manufactured from coil, it could require many extra weld tests to comply fully with ASME qualifications. With the added language, coil materials used in C200 pipe can now be qualified in the same manner as other steel products under ASME Section IX.

For materials over ¾ inch thick, side bends in accordance with ASTM A370 were added as an allowable bend test. It was also clarified for weld tests to complete two etch tests, previously a required quantity was not noted.

There were numerous other small changes and editorial corrections made to the section to improve clarity of the standard.

Weld Quality (discontinuity, defect, and repair)

Definitions of discontinuities and defects were improved and clarified. A defect is a discontinuity that exceeds the limits given in C200 and must be either rejected or repaired.

The section on repair of welds was also expanded giving more guidance on proper repair of defects.

Other Pipe Types

Other steel pipe standards have historically been included in C200 for use in applications such as outlet piping. The new edition of C200 is no exception, however the list of other allowed pipe standards has changed. The new edition of C200 allows for other ASTM pipe grades, but has a new limitation of less than 36 inches in diameter for these materials. The list also no longer includes pipe manufactured to ASTM A134 or ASTM A139. The use of steel in accordance with ASTM A139 is now covered in Table 1 of C200 (see Figure 7). ASTM A106 was added to the list as well as a very limited list of API 5L pipe. For API 5L pipe to be acceptable, it must include the API monogram to verify it has come from an API certified facility. It also has been limited to PSL 1 and PSL 2, as well as grades, X42 through X60. These limitations were placed on the pipe to insure a quality product as well as to keep material properties of the API pipe within the same range as the steel listed in Table 1 of C200.

Thickness

Allowable thickness variation and tolerances of steel used to manufacture C200 pipe have been listed in the standard since the first AWWA 7A standards were written. An allowable 0.01 in. undertolerance and no practical limits on over tolerance of the steel has always been included, but there has been confusion about when this should be applied. The 2012 version of C200 further clarifies the allowable steel tolerance issue in the body of the text. In general, unless specifically mentioned in the project specification or purchase documents to the contrary the tolerance limits in C200 will always apply. The undertolernace in C200 have also been modified from previous version to reflect the impact of the 0.01 in. tolerance on steel with thickness less than 0.167 in. by adding that the allowable undertolerance is the lesser of 0.01in., 6% of the steel thickness or the applicable ASTM standard undertolerance for nominal steels. These enhanced limits tighten up the allowable undertolerance, first with the 6% limitation, which means for steels ordered to less than 0.167 inch thickness, the undertolerance will be less than 0.01 inch.

Gaskets

The testing and material requirements for rubber gasket materials in the standard were significantly updated and modified. The new requirements for gasket materials adds tests for ozone resistance and water immersion;, many other testing requirements were also updated. Manufacturing tolerances that need to be verified for gasket materials have been expanded and now include tight diametrical limits. Gasket splice testing has been updated and requires each splice to be tested. There are also added requirements to assist in gasket material tractability, including requirements to include identification markings on the gaskets.

Offsets

Permissible plate offset during the welding of pipe has been modified. It now has a specific procedure for measuring any offset. The allowable offsets have been brought in line with other fabrication standards, such as AWS D1.1 and ASME Boiler Pressure Vessel Code (BPVC) Section VIII and a figure detailing the limits of offset has been added to the standard. The allowable repair methods of offsets exceeding the limits have also be clarified.

Steel

The list of allowable ASTM grades of steel found in Table 1 of AWWA C200 (see Figure 7) has been updated, both to match the current ASTM standards and to include the commonly used plate material ASTM A516, as well as clarifying the use of coil material ordered to the ASTM A139 standard. A note has been added to Table 1 of C200 in order to facilitate future ASTM types or classes of materials added to specific grades of coil materials.

Throughout the standard, language has been added to emphasize all steels used for AWWA C200 pipe must be of fine grain practice and fully killed, which will ensure the highest quality of steel being used.

Steel plate, sheet, or coils for fabricated pipe[1,2]

Specification	Grade	Minimum Yield Point *ksi (MPa)*
ASTM A36/A36M	Steel Plate	36 (248)
ASTM A139/A139M	B	35 (240)
	C	42 (290)
	D	46 (317)
	E	52 (359)
ASTM A283/A283M	C	30 (207)
	D	33 (228)
ASTM A516/A516M	55	30 (205)
	60	32 (220)
	65	35 (240)
	70	38 (260)
ASTM A572/A572M	42	42 (290)
	50	50 (345)
ASTM A1011/A1011M	Structural Steel (SS)	
	30	30 (207)
	33	33 (228)
	36	36 (248)
	40	40 (276)
	45	45 (310)
	50	50 (345)
	55	55 (380)
	High-Strength–Low-Alloy Steel (HSLAS)	
	45	45 (310)
	50	50 (345)
	55	55 (380)
	High-Strength–Low-Alloy Steel With Improved Formability (HSLAS-F)	
	50	50 (345)
ASTM A1018/A1018M	Structural Steel (SS)	
	30	30 (207)
	33	33 (228)
	36	36 (248)
	40	40 (276)
	High-Strength–Low-Alloy Steel (HSLAS)	
	45	45 (310)
	50	50 (345)
	55	55 (380)
	High-Strength–Low-Alloy Steel With Improved Formability (HSLAS-F)	
	50	50 (345)

NOTES:

1. For the ASTM grades listed in this Table, all type, limit, and class designations are acceptable.
2. All listed steel shall be fully killed and conform to fine-grain practice.
3. Steel shall meet chemical and physical properties as required in sections 6, 7, and 9 of ASTM A139.

Figure 7 : Table 1, AWWA C200-12

Charpy Testing

An entire section was added to the standard to clarify the use of Charpy testing for steel. Charpy testing should be evaluated when a pipeline is restrained. Charpy test results are an indication of a material's ability to absorb energy and can give some perspective as to the actual toughness of a material. This property is key in above ground cold weather environments. Typically these tests are done at the steel mill at the same time as yield and tensile tests and are included on the material test report (MTR) from the steel mills.

The evaluation found in C200 requires reviewing the minimum operating temperature or using 30 degrees F if the operating temperature is not known. The type of steel is reviewed to see if it is included in Table 1 materials of C200 and if the steel thickness is greater than ½", Figure 1 of C200 can then be utilized to determine the necessity of Charpy testing. Materials less than ½" do not require Charpy testing.

When Charpy testing is required, the frequency of testing, location and required values are listed in the standard. The requirements are two tests per heat lot located on the outerwrap and they must meet 25Ft-Lbs minimum.

The Charpy test criteria now found in the standard is based on the evaluation for Charpy tests found in ASME BPVC Section VIII.

Conclusions

AWWA C200 is a living, industry consensus document that has been improved and refined during each revision since the first AWWA publication in 1940 of a steel water pipe standard. The standard has changed with improvements in technology, knowledge, manufacturing capabilities and available materials. The newly revised AWWA C200-12 has many changes that have strengthened the standard by clarifying various issues, as well as refining the required material property and testing standards to the most advanced and latest available in the industry.

Steel and gasket standards have been updated. Testing requirement for steel, welds, gaskets and finished pipe have been updated and clarified. Straightness, thickness and weld offset requirements have been revised and expanded. These improvements will lead to a better understood, and technically stronger document for use by engineers and owners in order to specify high quality AWWA C200 water pipe in their water systems.

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