Section 1

AMERICAN Standards

Summary of Standards for Ductile Iron Pipe and Ductile Iron Fittings

Most of the Standards covering pipe and fittings manufactured by American Cast Iron Pipe Company have been prepared by the American Water Works Association Standards Committee A21. Applicable Standards, other than those developed by the A21 Committee, generally cover specialties or refer to ANSI Standards.

In order to take advantage of modern metallurgical science, better testing methods, improved production control, materials with better physical properties, and improvements in manufacturing methods, the A21 Committee has a continuing program for keeping its Standards revised to include the latest proven developments.

Development of Standards

The AWWA Standards Committee A21 on Ductile and Gray Iron Pipe and Fittings was organized in 1926 under the procedures of the American Engineering Standards Committee. It was reorganized under American Standards Association Procedures in 1955, and in 1984 it became a member of the AWWA Committee structure.

The Committee is responsible for the development of standards and manuals for ductile iron pressure pipe for water and other liquids and for fittings used with such pipe. The Committee's membership is comprised of representatives from consumer groups, producer groups and general interest groups.

A standard, manual or revision is developed by a subcommittee assigned to that task. The subcommittee prepares and submits the document to the Standards Committee for approval. After approval it is then submitted to the AWWA Standards Council for approval. After all approvals have been received, including a public review by both AWWA and ANSI, the standard, manual or revision is published and made available to the public.

Specification History

A brief review of the older specifications in chronological order may help define their usefulness, as well as help in the appreciation of the improved modern standards.

Abbreviations of Organizations

The following is a list of the organizations referred to in this Section and other Sections of this Manual by abbreviation.

American Association of State Highway and Transportation Officials	AASHTO
Alloy Casting Institute	ACI
American Gas Association	AGA
American Iron and Steel Institute	AISI
American National Standards Institute	ANSI
American Petroleum Institute	API
American Society of Civil Engineers	ASCE
American Society of Mechanical Engineers	ASME
American Society for Testing and Materials	ASTM
American Water Works Association	AWWA
Ductile Iron Pipe Research Association	DIPRA
Ductile Iron Society	DIS
Factory Mutual System	FM
International Organization for Standardization	ISO
United States Military	MIL
New England Water Works Association	NEWWA
NSF International	NSF
Underwriters Laboratories	UL
Water Environment Federation	WEF

The basis for design in almost all specifications to date is the Barlow formula, or "Hoop Stress" formula. It embodies the basic principle for design of a thin cylinder for internal pressure. The formula may be stated as:

$$t = \frac{pd}{2S}$$

in which t is the thickness of the pipe in inches; p is the internal pressure in pounds per square inch (psi); d is the inside diameter in inches; and S is the allowable working stress of the metal in pounds per square inch.

In the development of the design of cast iron pipe, this formula has been modified in several ways by prominent water works engineers such as Allen Hazen, Thomas H. Wiggin, James T. Fanning, Dexter Brackett, I. J. Fairchild and James P. Kirkwood. Mr. Kirkwood, as chief engineer for the Brooklyn Water Works, developed a design for cast iron pipe which was a variant of the Barlow formula. Kirkwood's calculations took into consideration casting imperfection, corrosion, strength of the metal and other factors affecting the life of the pipe. In the late 1880s, a formula by Dexter Brackett, distribution engineer for the City of Boston, was adopted by the New England Water Works Association as their standard. The formula is as follows:

$$t = \frac{(p + p1)r}{3{,}300} + 0.25$$

in which t is the thickness of the pipe wall in inches; p is the static pressure in psi; p1 is the pressure allowed for water hammer in psi; r is the internal radius of the pipe in inches; 3,300 is equal to one-fifth the tensile strength of cast iron, taken as 16,500 psi; and 0.25 is an allowance for corrosion and foundry tolerance in inches. Brackett accordingly used a safety factor of 5 in his formula.

Although the 1902 NEWWA specifications did not provide a formula for pipe thicknesses, the Brackett formula was used in determining the thicknesses recommended.

The AWWA in 1908 adopted a standard covering bell and spigot pipe produced in 12-foot laying lengths by the pit casting method. Prior to 1908, at least two unofficial documents dealing with pipe design were acknowledged by AWWA. The first of these used thicknesses for pipe determined by averaging the thicknesses used in a large number of American cities. The second dealt with actual design of pipe based on Brackett's method with variations.

The 1908 AWWA standards employed a system of class designations applied to specific wall thicknesses in diameters 4" through 84" inclusive for a range of hydraulic heads. The most common of these classes were A, B, C and D for 100-, 200-, 300- and 400-feet hydraulic head, respectively. The design was based on a variation of the Brackett formula by J. T. Fanning and included a variation in the outside diameter for the different classes of pipe. The basic design of pipe with a different outside diameter for each class was followed in modern specifications until the 1961 revisions. The general acceptance by the water works industry of the standardized mechanical joint necessitated a standard outside diameter for cast iron pipe.

AWWA revised their standards in 1939 to incorporate a new method of designing cast iron pressure pipe. This new method was published as ANSI A21.1. The A21.1 method of determining the required thickness of cast iron pipe takes into consideration trench load and internal pressure in combination. Trench load consists of the earth load on the pipe plus any superload resulting from traffic over the trench; internal pressure consists of the design working pressure plus an additional allowance for surge pressure. Laying conditions and strength of the iron in the pipe are also factors involved in the design. Additions for casting tolerance and a corrosion allowance are included in the design thickness.

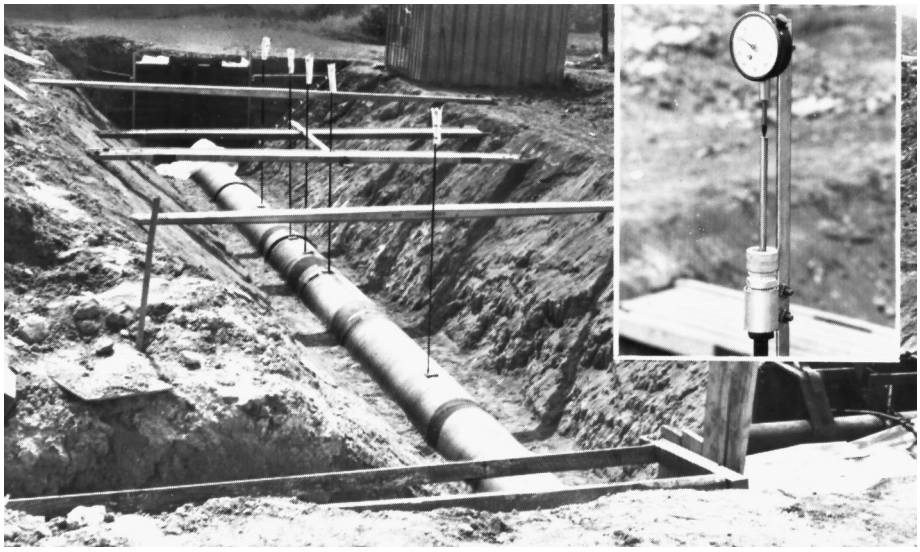
Actually, the first standard covering centrifugally cast pipe was issued by the United States Government in 1927, and was known as the Federal Specification No. 537. In July 1931, the specification was revised to include pipe cast centrifugally in

sand-lined molds, pipe cast centrifugally in metal molds, and pit cast pipe. This specification has been modified several times and now is basically the same as ANSI/AWWA Standards.

Development of ductile iron in the 1950s initiated research into design of ductile iron pipe to take advantage of the superior strength, toughness, impact resistance and corrosion resistance of this new metal. The A21 Committee issued the ANSI A21.50 (AWWA H3-65) and ANSI A21.51 (AWWA C151) Standards for ductile iron pipe in 1965. The work of Prof. M. G. Spangler and others at Iowa State University on flexible conduit is the basis for principles that have been applied extensively by the designers of flexible underground pipe. The design principles and procedures for ductile iron pipe that were included in the ANSI Standard A21.50 (AWWA C150) were verified by actual trench tests at AMERICAN and by tests conducted by various researchers.

Continued research on ductile iron pipe reflects through these updated standards the advancements in metallurgical technology and manufacturing skills. Furthermore, the quality of AMERICAN's products and conformance to appropriate specifications are assured by the British Standards Institute's certification that AMERICAN's quality system complies with ISO 9001 Quality Management System Standard.

AMERICAN also subscribes to NSF's listing program for products under ANSI/NSF Standard 61—Drinking Water System Components—Health Effects. Check AMERICAN for current listing of our products.



Tests were conducted at AMERICAN on an installation of five 36" Special Class 51 AMERICAN Ductile Iron Fastite® Joint pipe. Trench is shown with pipe backfilled to spring line and ready for placement of 8' earth cover over the pipe, in a wide trench condition. The ends of the trench were provided with thrust blocking so that the pipeline could be hydrostatically pressurized for testing. Instrumentation consisted of vertical and horizontal deflection gauges, soil pressure gauges, SR-4 electric strain gauges and a hydrostatic pressure gauge. The results of this testing confirmed the applicability of flexible pipe design to ductile iron pipe and became the basis for the first national standard for ductile iron pipe, ANSI A21.50 — 1965 (AWWA H3-65), "American Standard for the Thickness Design of Ductile Iron Pipe." Inset — Vertical deflection gauge which measured vertical deflection of the pipe, as well as the amount of embedment of the pipe into the trench bottom.

Standards Applicable to AMERICAN Pipe and Fittings

Throughout this Manual, Standards may be referred to as listed below or by only the ANSI, AWWA, ASTM, NSF, ASME, etc. numbering.

Ductile Iron Pipe for Water and Other Liquids:	
4″ through 64″	ANSI/AWWA C150/A21.50 ANSI/AWWA C151/A21.51
Ductile Iron Gravity Sewer Pipe:	
4″ through 64″	ASTM A746
Ductile Iron Culvert Pipe:	
14″ through 64″	ASTM A716
Ductile and Gray Iron Fittings for Water and Other Liquids:	
4″ through 48″	ANSI/AWWA C110/A21.10
Ductile Iron Compact Fittings:	
4″ through 64″	ANSI/AWWA C153/A21.53
Flanged Pipe:	
4″ through 64″	ANSI/AWWA C115/A21.15
Coatings and Linings:	
Asphaltic	ANSI/AWWA C110/A21.10 ANSI/AWWA C115/A21.15 ANSI/AWWA C151/A21.51 ANSI/AWWA C153/A21.53 ASTM A716
Cement Lining	ANSI/AWWA C104/A21.4 ASTM A746
Ceramic Epoxy	PROTECTO 401 ASTM A746
Coal Tar Epoxy Lining	PROTECTO 401
Polyethylene Encasement	ANSI/AWWA C105/A21.5 ASTM A674
Joints — Pipe and Fittings:	
Fastite®	ANSI/AWWA C111/A21.11
Mechanical	ANSI/AWWA C111/A21.11
Flanged	ANSI/AWWA C110/A21.10 ANSI/AWWA C115/A21.15 ANSI/AWWA C153/A21.53
Grooved and Shouldered	AWWA C606
Other joints shown in this Manual are AMERICAN design.	
All Products*	ANSI/NSF Standard 61

*Check AMERICAN for current NSF listing of AMERICAN products.

NOTE: Many AMERICAN joints, classes of pipe, fittings, and specials are listed by Underwriters Laboratories Inc. and Factory Mutual System. The quality of AMERICAN's products and conformance to appropriate specifications are assured by the British Standards Institute's certification that AMERICAN's quality system complies with ISO 9001 Quality Management System Standard.

Standards for the Design, Manufacture, Installation and Certification of Ductile Iron Pipe and Ductile Iron Fittings

Standard Designation	Subject
ANSI/AWWA C104/A21.4	Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
ANSI/AWWA C105/A21.5	Polyethylene Encasement for Ductile-Iron Pipe Systems
ANSI/AWWA C110/A21.10	Ductile-Iron and Gray-Iron Fittings, 3 in. through 48 in., for Water
ANSI/AWWA C111/A21.11	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
ANSI/AWWA C115/A21.15	Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges
ANSI/AWWA C150/A21.50	Thickness Design of Ductile-Iron Pipe
ANSI/AWWA C151/A21.51	Ductile-Iron Pipe, Centrifugally Cast for Water
ANSI/AWWA C153/A21.53	Ductile-Iron Compact Fittings, for Water Service
ANSI/AWWA C600	Installation of Ductile-Iron Water Mains and Their Appurtenances
ANSI/AWWA C606	Grooved and Shouldered Joints
ASTM A674	Polyethylene Encasement for Ductile Iron Pipe for Water or Other Liquids
ASTM A716	Ductile Iron Culvert Pipe
ASTM A746	Ductile Iron Gravity Sewer Pipe
ANSI/NSF 61	Drinking Water System Components—Health Effects
ASTM G62	Standard Test Methods for Holiday Detection in Pipeline Coatings

Miscellaneous Standards

The following Standards are related to ductile iron and gray iron piping but are generally not directly applicable to the manufacture of AMERICAN pipe and fittings.

Standard Designation	Subject
ANSI A40.5	Threaded Cast-Iron Pipe for Drainage, Vent, and Waste Services
ANSI/ASME B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
ANSI/ASME B16.1	Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800
ANSI/ASME B16.3	Malleable-Iron Threaded Fittings, 150 and 300 lb
ANSI/ASME B16.4	Cast-Iron Screwed Fittings, 125 and 250 lb
ANSI/ASME B16.5	Pipe Flanges and Flanged Fittings
ANSI B16.12	Cast Iron Threaded Drainage Fittings
ANSI B16.14	Ferrous Pipe Plugs, Bushings, and Lock-nuts with Pipe Threads
ANSI B16.21	Nonmetallic Flat Gaskets for Pipe Flanges
ASME/ANSI B16.42	Ductile Iron Pipe Flanges and Flanged Fittings
ANSI B18.2.1	Square and Hex Bolts and Screws, Inch Series
ANSI/ASME B18.2.2	Square and Hex Nuts (Inch Series)
ANSI B31.1	Power Piping
ANSI/ASME B31.8	Gas Transmission and Distribution Piping Systems
ANSI/ASME B1.20.1	General Purpose Pipe Threads
ANSI/AWWA C207	Steel Pipe Flanges for Waterworks Service - Sizes 4 in. through 144 in.
ANSI/AWWA C500	Gate Valves - 3 in. through 48 in. NPS, For Water and Sewage Systems
ANSI/AWWA C501	Sluice Gates
ANSI/AWWA C502	Dry-Barrel Fire Hydrants
ANSI/AWWA C503	Wet-Barrel Fire Hydrants
ANSI/AWWA C504	Rubber-Seated Butterfly Valves
ANSI/AWWA C508	Swing-Check Valves for Ordinary Waterworks Service
ANSI/AWWA C509	Resilient-Seated Gate Valves for Water and Sewage Systems
ANSI/AWWA C550	Protective Interior Coatings for Valves and Hydrants
ASTM A48	Gray Iron Castings
ASTM A74	Cast Iron Soil Pipe and Fittings

Standard Designation	Subject
ASTM A126	Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A278	Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650°F (345°C)
ASTM A319	Gray Iron Castings for Elevated Temperatures for Non-Pressure Containing Parts
ASTM A377	Standard Index of Specifications for Ductile Iron Pressure Pipe
ASTM A395	Ferritic Ductile Iron Pressure Retaining Castings for Use at Elevated Temperatures
ASTM A438	Transverse Testing of Gray Cast Iron
ASTM A476	Ductile Iron Castings for Paper Mill Dryer Rolls
ASTM A518	Corrosion-Resistant High-Silicon Iron Castings
ASTM A536	Ductile Iron Castings
ASTM A571	Austenitic Ductile Iron Castings for Pressure Containing Parts Suitable for Low-Temperature Service
ASTM C150	Portland Cement
ASTM D1248	Polyethylene Plastic Molding and Extrusion Materials
ASTM E8	Tension Testing of Metallic Materials
AASHTO M64	Cast Iron Culvert Pipe
AASHTO M105	Gray Iron Castings
AWWA D100	AWWA Standard for Welded Steel Tanks for Water Storage

Standards Notes

Standards Notes

AMERICAN reserves the right to modify or change designs, materials, specifications, or dimensions shown herein without prior notice.

This is a preprint of a section from the 19th Edition of the AMERICAN Pipe Manual. References may be made in this section to other sections of this manual.